The Challenge of Transformation of Indian System(s) of Innovation

Dinesh Abrol[1]

1. Introduction

Studies on the dynamics of national system of innovation (NSI) are still few and far between to become a significant theme for research based discourse in the Indian academic world[2]. Even the policymakers are not keen to engage as yet with the academics on the issues concerning the impact of reforms on the national systems of innovation (NSI) in India. Some policymakers certainly have become active on the issue of getting the government to step up the public funds for scientific research in the publicly funded R&D system[3]. Otherwise mostly discussions among the Indian policymakers on the impact of reforms undertaken during the period of last two decades have been self-congratulatory[4]. An important academic task before the NSI community is therefore to get the policymaking world to engage with the concerns being raised by us on the post-reform achievements of NSI in India.

This article undertakes the challenge of relating the emerging academic findings on the post-reform achievements and limitations of NSI to the earlier Indian academic discourse on liberalization with which the policymaking world had actively connected to obtain legitimacy for the policy of liberalization at the time of the start of reforms in the mid eighties. It brings out that currently the policymaking world appears to be discussing the achievements and limitations of the NSI by assuming implicitly as if the chosen route of reforms is essentially correct and needs only some corrections at the level of public funding in basic science, venture capital and other such measures to be taken up by the nation state in respect of science, technology and innovation (STI) to achieve the desired outcomes. Policymakers are going overboard with the achievement of just an average of six percent rate of economic growth[5]. The obvious limitations of a growth path in which the route of outsourcing is visibly the engine of

---

[1] NISTADS

[2] See the studies undertaken by the currently active academics: Rishikesh Krishnan (2001, 2004, 2005)), Sunil Mani (2001, 2004, 2005), R. Basant (1999, 2002, 2004), K Joseph (2004), Sunil Mani and Nagesh Kumar (2002), V.V Krishna (2002), Ardhana Aggarwal (2004) and Dinesh Abrol (1997, 1998, 1999, 2002, 2004) Most of these have been already presented in the Globelics meetings.

[3] Concerns raised by CN R Rao, N Balaram are of this nature and have been responded to by the government in a way by giving a higher level of support to the Indian Institute of Science and sanctioning one more science institute to be located near Kolkatta.

[4] In the Indian parliament discussions on the S&T budget are a rare occurrence. It is notorious for the guillotine being put on the S&T budget discussions. In the party political circles, S&T debate is an exception. Consensus on the S&T priorities and outcomes is a rule. Even the latest programme of UPA government (NCMP) in respect of S&T is only a paragraph long. No questions and complete autonomy to the scientists and S&T institutions is the order of the day.

[5] First of all, they have suggested that the period of liberalization has to be divided into two phases. The rates of growth achieved during the phase of internal liberalization are no less when we compare them with the performance achieved during the phase of external liberalization. They point out that the growth performance of the phase of internal liberalization with the period after 1990s the phase of external liberalization is yet to surpass the rates of growth achieved during the eighties. In a way through this argument on the rates of growth these academics are also questioning indirectly the claims being made about the proven nature or correctness as such of the policies of external liberalization, privatization and global integration of the structures of science, technology and innovation.

growth does not seem to be bothering them much[6]. Concerns being raised on the patterns of growth composition, structure of demand including domestic demand size, incentives and institutions for the establishment of interactions and flow of knowledge among the firms and organizations and other such determinants of the dynamics of NSI in India are not yet on their active agenda.

Section 1 brings out that in the academic discourse carried out at the start of the reforms by both, the advocates of liberalization as well the opposing side, academics and policymakers alike had spoken of the reforms to target the stimulation of 'major innovations' as a major task. The side arguing for liberalization believed that to accomplish this task changes in the policies would have to target the problem of insufficient number of 'large firms' and their freedom to follow up on the prospects of profit. In the emerging academic discourse where differing claims persist regarding the achievements and limitations of the national system(s) of innovation, the nature of contribution that the corporate sector has made or is able to make to the development and diffusion of major innovations in the economy and society is however still to become an area of debate.

In Section 2, this article also focuses therefore on the question that as to what extent the large private sector firms that have now complete freedom, are being able to contribute to the development and diffusion of new technology. In what way they have tackled the issue of introduction of major innovations in the Indian economy on the basis of home grown capabilities, be acquired through the absorption of technology imports or developed through indigenous efforts. It also points out that by offering a description of the evolution of NSI in the post-reform period and assessing the emerging structure with the help of the indictors such as growth in production based on new technologies (IT & BT), R&D efforts, patents and patent applications, educational system, availability of venture capital and so on the engagement with the challenge put forward in the earlier academic discourse remains unfulfilled.

In Section 3, this article suggests that we will have to also ask whether the national and state level systems of S&T that are publicly funded are taking an appropriate direction of R&D effort and the role that the policymakers can expect these structures to perform in the future in the case of Indian NSI. It suggests that as there is a systemic connection of the evolving national system of innovation with the inequalities emerging in the co-evolving socio-economic system the theoretical framework should be updated to incorporate the dimensions of growing inequality, control of the resources for innovation shifting from the government to the corporate world, societal needs being ignored by the practitioners of science and technology based innovation, etc., with the aim to include it in the empirics being explored in the current academic discourse.

[6] Policymakers seem to be totally convinced of the success of reform measures and are announcing from all kinds of platforms how India will be a developed country by the year 2020. Abdul Kalam, formerly the Chairperson of Science Advisory Council and currently the President of Indian republic is well known for making such statements. Similarly, Manmohan Singh, currently the Prime Minister, who was responsible in the early nineties for shifting the country from the path of internal liberalization to external liberalization, is also overenthusiastic about the success of reforms in the sphere of S&T and is ready for further openness in the areas of even food and energy. Even though imports in these two spheres are increasing, his government is getting ready to enhance the global integration of S&T in both these spheres.

In Section 4, it argues that the latest evidence on NSI dynamics is required to be debated by embedding the empirics in an updated theoretical explanation because the earlier discourse had understood the problem of technological performance to be a question of merely how to stimulate the in-house technological capabilities and behaviour of a large firm for the introduction of major innovations. It suggests that using a non-heroic approach to technical change the updated theoretical framework should be capable of providing a systemic explanation of the failures and successes and incorporate evidence on the performance of functions of the innovation systems connected with the creation of technological knowledge, systems of competence building, learning and innovation; articulation of demand, regulation and formation of markets; prioritising of public and private sources and supply of resources for innovation and development of appropriate mechanisms for advocacy and regulation of technological change.

Section 1:Academic discourse on the nature of reforms to be undertaken for the NSI transformation in the mid eighties

From the discourse carried out on the dynamics of national system(s) of innovation (NSI) on the eve of reforms in the mid eighties, the following three issues emerge in a quite prominent way for our consideration today: a) the nature of challenge laid in respect of the type of innovation (s) and competences to be achieved in the future, b) the points of differences and agreement among the participants in the discourse that are relevant to the outcomes obtaining in respect of the innovations undertaken and c) the points ignored by the earlier discourse but highly relevant to understanding the actually observed behaviour of concerned actors and impact of the policy changes.

1.1 The challenge in respect of innovation and competence building

India is known to possess an intermediate level of S&T capabilities and a large part of these S&T capabilities were certainly accumulated during the period of pre-liberalization policy regime. For the organization and management of these capabilities efforts were mainly carried out by those structures of S&T that were established and nurtured during the same pre-liberalization period. But today a significant part of the literature is quite depreciative of the achievements of pre-liberalization period. Even those who are more careful have been uncritically accepting the viewpoint of the advocates of liberalization that the government was hostile to the corporate sector during the pre-liberalization period and the governmental S&T system was altogether de-linked from the enterprise sector in India. The worse off you can show the past, the better off appears the present. It is self-serving argument for the advocates of reforms because arguing that the economy was in bad shape will help credit all the improvement to the efforts of external liberalization and deregulation.

However, it cannot be forgotten that even those very academics that favoured the policy of external liberalization did accept the fact of incremental or minor innovations being undertaken in the economy. They accepted that at least during the period of pre-liberalization policy regime India had developed industrial capabilities across the sectors for both, production operations and investment. The challenge laid before the policymakers was one of formulating changes in the pre-liberalization regime with the aim to stimulate and create conditions for a much wider diffusion of major innovations in the Indian economy.

Bhagwan (1982) who was an active contributor from the side opposing external liberalization had made a study of the capital goods sector in 1979-80. This study attempted to assess the nature of product and process innovations carried out in ten of the largest firms in each of the three sectors of machine tools, heavy electrical and chemical equipment manufacture. Bhagvan came to conclusion in this study that technological innovations of a major kind were lacking. The concept of 'major' innovation used was based on what the firms themselves thought were 'major' in terms of cost, time taken, importance of sales, etc. Bhagvan lists 110 innovations made by the firms covered in the sample, 40 had taken three or more years from the state of conceiving the initial idea to the prototype stage. The rest of innovations had taken two year or less. On the basis of time taken to complete the innovations and the total R&D investments dedicated by the firms in the sample, Bhagvan concludes that about two thirds of the innovations cited by the Indian capital goods firms were really minor technical changes, adaptations and improvements.

Debate was about whether the cost incurred to achieve this technological mastery was high and could have been reduced by opening up and liberalising the internal market. It is possible to cite here the contributions of Ashok Desai who worked on the state of innovations in India during the seventies and eighties and advocated for the removal of governmental controls to stimulate innovations in the economy. Among the Indian academics Ashok Desai was a key votary of the adoption of a policy of external liberalization and considered explicitly the nature of challenge in respect of innovation. Desai believed that imitation has been the basis of new competition in Indian industry and major innovations have been discouraged due to the absence of large firms. Incremental innovations have been dominating the scene and are costing the country quite heavily. Desai described four points of origin of in-house R&D in firms in India-quality control, technical services, material adaptation and plant and equipment construction. Desai (1987) notes a high proportion of Indian corporate R&D to be also devoted to developing new products (product differentiation, related product but minor innovations) on the basis of imported technology. While making an assessment of the improvisations practised which had raised in his view the costs of technological mastery for India, Desai (1987) stated that whilst import-processing and import-replacing firms have not disappeared altogether the improving firm has become the leading element.

But when Desai (1987) described the improvisations that the Indian firms attempt to be of two major types and characterised as scale adaptation and market adaptation, his work was countered and shown to be far from adequate to describe the changing situation of seventies. Sinha (1983) differed and found the Desai's typology to be inadequate. Sinha suggested that this typology was empirical and applicable to 1950s and 60s environment only and constructed a typology using two principles-elements of technology and relatedness. Sinha included much finer categories such as : new products unrelated to existing product in technology and function, new products related in technology but not in function to some existing product, improved model of existing product, product of capacity and beyond and the range for which the firms possessed standard designs, development of process (or part of the process) of manufacturing an existing product, utilizing unconventional self-fabricated equipment for the manufacturing system, etc. Using this typology, Sinha (1983) shows that during the period 1971-81 product innovation effort predominated in most industries. Sinha believed that product R&D observed in the case of new industries in India is

actually a case of reversal of the usual pattern of sequencing of innovative output in the industry life cycle observed in other countries-reproduction of product, output augmenting improvements, process improvements and new products. Sinha (1983) gave credit for the predominance of product R&D in his sample to the changed environment and the internal liberalization of domestic market that the government had started practising in the case of some activities in India during the decade of seventies itself[7].

Abrol (1989) argued that the above-described evidence of reverse sequencing is also attributable to the sample bias of the firms studied by Sinha (1983) for being active in industries that are highly sensitive to user requirements. However, it is not correct to treat all the adaptations of imported technology to be only a regression or downgrading of imported technology, as characterised by Desai. It was stated that we couldn't judge innovative behaviour only in terms of the vertical movement made across the trajectory. Abrol (1989) considered this treatment to be inadequate because the way it considered the question of technological opportunity for a country of sub continental size requiring to use these adaptations for the benefit of technical change in the Indian industry as a whole among both large and small firms. Abrol (1989) was of the view that the impact of market and scale adaptations cannot be always considered as a reduction in the standards of quality. He suggested that in India the impact of both market and scale adaptations on the development of backward linkages including the production of intermediate inputs and components should be taken into account. These impacts have not been realized in a big way because the industry has not been able to tackle the problem of technological fragmentation. He considered the role and function of technological coordination to be quite critical to the introduction of major innovations.

1.2 Characteristics of firms, market structure and innovative behaviour

It is clear that the debate at the time of the start of reforms was certainly not on the fact of whether or not innovations were occurring in the Indian industry but on how the market environment and resources for the introduction of major innovations would be created in a country like India on a consistent and virtuous basis. Scholars not only recognised this weakness to be a significant failure of the pre-reform period but also deliberated on the reasons for how the Indian system(s) of innovation are not able to introduce major innovations. Characteristics of firms in terms of the attributes such as ownership and size, nature of market environment and the role of state, these three determinants were deliberated upon in this academic discourse for almost a decade.

The advocates of liberalisation held the view that the innovations made had contributed to the deterioration of industrial performance. They indicated that the breadth and depth of capabilities created by the previous policy regime could have been achieved at a lesser cost if there was free flow of foreign technology from foreign sources in to Indian industry. They suggested that with a more open trade policy including technology the industry could have obtained from foreign sources

[7] In fact it would not be incorrect to point out that the Indian economy was a mixed economy all through the 'pre-reform period'. The private sector was in position to diversify and capture the new product space arising in quite a few of the new activities. Gradually the market environment was changing and these changes did have an influence on the technological behaviour of all the firms including private sector firms.

most of the local capabilities it has built (Desai, 1988). The opposite side held that although the foreign technology-finance nexus of Indian industry had retarded the acquisition of capabilities, on the whole the earlier strategy was effective because it contributed to the absorption, adaptation and diffusion of foreign technology. In their view, the innovations wherever introduced, had positively contributed to the industrial policy (Subramanian, 1987). The advocates of opposite side proposed restraint with regard to the lifting of controls on foreign capital and technology, gradual reduction of controls on internal competition, increased government procurement of products based on new technologies from local sources, larger support for the expansion of internal markets through increased public investment and changed composition of growth, stronger linkages between public S&T capabilities and industry and incentives to industry to invest more in R&D for major innovations (Subramanian, 1991).

Firm size was one of the most important determinants of innovative behaviour for the advocates of liberalization. Desai held this view that in India the most important factor affecting the accumulation of firm's capabilities is their small size. Desai (1987) argued that "on the one hand, size constrains their capacity to invest in innovation and on the other hand, it makes them vulnerable to competition, increases their perceived risks, and makes them ignore long term objectives, which include innovation. Consequently, policies promoting small scale units, anti-monopoly policies and industrial licensing and trade policies which discriminate against the firms which are first to import technology militate against technological dynamism through their effect on large firm's prospects for profit." Subramaniam (1988), a leading academic on the opposite side, had however a different view that it is only the compulsive environment created by the government controls which induced the progressive firms to become technologically self-reliant more than their own effort. Fiscal and other economic policies of the government have provided incentives for inplant R&D and indigenisation. Of course, in taking this position he had utilized mainly the observation that the expenditure on R&D increased faster than payments on account of technology import by foreign collaborations in the Indian industry during the semi-insular period. But all the same he also conceded in his work that in India the proportion of large firms with the capacity to introduce autonomously major innovations was small (Subramaniam, 1988).

Scholars on both sides of the policy divide had got into this question of the significance of the firm size for innovations introduced during the period of pre-liberalization. Evidence collated by Bhagwan (1983) indicated that "the largest firm has a tendency to lag behind in the terms of contribution of innovation based on local technological effort". Bhagwan (1983) stated that "the larget firm in both sectors, heavy electrical equipment manufacture and chemical equipment manufacture, did quite poorly in terms of the contribution to technology. Firms somewhat lower down the scale in size did more relevant and original innovations than the largest firms." Bhagwan provides following reasons for the observed phenomenon of the firms down the scale being technologically more active. Bhagwan (1983) stated, "The giant firms have monopolized the market for complex and very expensive equipment. In order to survive the others have to produce and sell other kinds of equipment, as the competition is quite keen. This competition spurs on innovation. He also states that in the middle sized firms it is still possible for the top management to keep a eye regularly on the progress otherwise of the R&D departments, whereas discouraging

apathy and active top management involvement are not possible in the giant firms in the present context, as their top and middle mnagers are caught up in bureaucratic and hierarchical thinking and practices, which are also replicated in their R&D.

C.P Chandersekhar (1988) stated that in production small scales are by no means the result of state control of large firms. He indicated "rather they appear to be the fall out of inadequate controls which leaves certain crucial aspects of the investment decision to be determined completely by market forces. If in such an environment private investors were not protected from international competition, they would in all probability have opted out of undertaking investments in the areas studied rather than set up viable capacities with the world market as their target. This was inevitable given the nature of the decision making unit in the corporate sector (conglomerates) and the context in which India entered the stream of industrialization".

Take the problem of over-diversification, which Desai thought was an adverse effect of the government policies on trade and licensing, particularly anti-monopoly policy and policy of the protection of small-scale units. Chandersekhar (1988) pointed out that in the case of firms belonging to business houses (conglomerate firms) there is a tendency of spreading risk by investing in a large number of products without exploiting the scale economies hen permitted. Goyal (1988) provided the evidence to the effect that the conglomerates have used extensively the licensing and controls to pre-empt the entry of others into a chosen field in the past, resulting in retrogressive technological situation. Goyal (1988) reports that in high technology areas, the de facto official policy was to grant licenses in a manner that the monopoly houses / TNCs could obtain exclusive monopoly in these fields to encourage them to bring technology required.

On the subject of competition spurred by imitation, it was pointed out that initiatives announced by the government to upgrade technology were never duly implemented to become a problem for the large firms. Further, it was also suggested that the claim of free rider type imitation making the large firms vulnerable does not hold in a general way. There are reasons to believe that in most of the cases the reverse may be true. In many cases imitation was shown o have facilitated saving of foreign exchange, creation of design capacity in capital goods producing firms, cheapening of intermediate inputs and a higher level productive use of factors available in abundance. Abrol (1989) suggested that stronger patent protection and foreign brand names use had not generated quality in pharmaceutical industry. Evidence was provided that large firms could indulge in the sale of poor quality and unsafe goods when the public control was weakened in the pharmaceutical and other consumer goods industry. It was argued that in large group (long chain) industries competition is based on favoured access to factor supplies, finance and licences, high level of image building activities and unethical restrictive sales promotion for the large firms. Evidence was provided that in many cases price policies of large firms are geared to keep the small firms margins to the minimum, which has led to obsolescence and lack of modernization of technology used by small-scale units. Abrol (1989) suggested that the policy of external liberalization might not lead to full exploitation of scale economies and x-efficiency by large firms in the large group industries. It might even result in the tendency of disinvestment from the technology intensive steps.

The ownership of firms, particularly the distinction between subsidiaries of foreign firms, domestic private firms and public enterprises, was shown to be also having a determining impact on issues such as the access to foreign sources of technology, finance and marketing or commercialization channels. Characteristic such as managerial structures and practices, relationship with labour and labour unions, etc., were shown to have an impact on technological innovation. The side arguing for external liberalization was of the view that foreign subsidiaries realize higher unit value per unit of output as well as higher capacity utilization than heir competitors though the difference was not significantly large (Desai, 1983). Desai argued that it is thus important to confer monopoly on the firms that import technology in the first instance because the above has shown that the size of market is very important for R&D, which is shown to be complementary to rather than competitive with technology imports. Abrol (1989) argued that we could also understand the realization of higher value per unit output to be associated with marketing capabilities and market power rather than a consequence of R&D.

Studies done by Subramaniam and Pillai (1975, 83 and 84) indicated a very different story in respect of foreign controlled firms. Their conclusions were opposite of what Desai had concluded regarding foreign controlled firms' technological behaviour. In an UNCTAD study of the Indian capital goods sector done by Pillai, Alagh and Subramaniam (1984) pointed out that there re significant differences across ownership categories in the pattern of technology import. Foreign subsidiaries and controlled firms were shown to have imported a higher number of technology elements in packaged forms. The impact on outflow of resources was higher in their case. Foreign controlled firms were found to be remitting to foreign licensors three times more than their R&D expenditure. The adaptive behaviour of the firms was found to be different across ownership categories. Foreign controlled firms and minority joint ventures were found to be renewing their licensing agreements with more alacrity, implying a high lead time for absorption and low degree of local adaptation compared to domestic firms. In their study on the role of MNCs in the building of technology capabilities in Indian pharmaceutical and electronics industry, Subramaniam and Pillai (1984) suggested that on the whole the profile of MNC controlled firms is one which orients itself to the changing patterns of global interests of the foreign parent organization. There is less integration with the productive structure with the result that the import content is high. Lesser emphasis on intra-mural research and greater emphasis on domestic marketing clearly reflect the motives of MNCs as being one of consolidating the oligopolistic leadership in the Indian market for quick returns rather than strengthening the technological base for stable growth.

Abrol (1989) opined that the academic discourse has been limiting the study of technological performance to the in-house capability building processes. Relations with suppliers and customers do not figure in the academic discourse. Interrelations and interactions among firms were not getting into the discourse on failures of the policy regime. Abrol (1989) suggested that studies undertaken on the connection (s) of market structure with innovative behaviour will have to be made far more comprehensive with regard to the explanatory variables. It was apparent that the side favouring external liberalization was ignoring the determinants such as the existence of monopoly power determined technology behaviour, business house behaviour due to the conglomerate nature of large firms, foreign control and ownership in large firms determining the incentives and disincentives for technological behaviour and the lack

or existence of public control determining the technology behaviour of large firms, etc.

In the earlier academic discourse, since both the sides had tended to treat the technological conduct as being constituted mainly by the in-house RDD behaviour and the behaviour relating to acquisition of imported technology, it is not surprising that they had an agreement on the issue of insufficient number of large firms being a key reason for the failures in respect of the introduction of major innovations. This raised an important question about how the state policies would have to be redefined to allow the firms to grow in size and favour them in respect of state support to enable the firms to remain capable of autonomous introduction of major innovations. In what way the state policies need to be reshaped to affect the technological performance and impact through the improved interactions and better systemic interrelations of domestic firms with the remaining productive structure did not find a focal point in the academic discourse undertaken in the mid eighties.

1.3 State, competence building and innovation in industry

In India, at the time of the start of reforms undertaken in the form of liberalization, privatization and deregulation, the policy debate was characterized by widely differing stances on the role of the state in the accumulation of scientific and technological capabilities and in the fostering of industrial S&T capabilities for the introduction of major innovations. The advocates of liberalisation argued that licensing policy, anti-monopoly policy, policies promoting small scale industry and trade policy incorporating phased manufacturing programmes have tended to increase the perceived risks of large private sector firms by making it uncertain whether and when they can follow-up prospects of profits and which in turn constrain firms capacity to invest in in-house R&D and make them ignore long term objectives including innovation (Desai, 1980, 84, 88). The opposite view took the position that per se government intervention and protection from foreign competition cannot be held responsible for the technical inefficiency and stagnation in Indian industry (Subramanian, 1987).

Their differences on the subject of policy regime to be followed in respect of the liberalization of trade, technology import and foreign capital were sharp and had an impact on the pace and sequencing of policy changes carried out as a part of reforms undertaken during the period of last two decades. The side arguing against external liberalization argued that as far as the internal development necessary for backup to the import of technology for adaptation, assimilation and diffusion is concerned broadly the earlier strategy was reasonable and effective, but for the foreign finance technology nexus which restricted the pace of adaptation, assimilation and diffusion of technology. Subramaniam and Pillai (1976) were of the view that the transnational corporations (TNCs) are unwilling to part with know-why and they impose restrictive conditions, which tend to work against the absorption and diffusion of foreign technology in the national productive system. Subramaniam compared the RBI surveys and had taken a view that the assets transferred under collaboration agreements had reduced after the implementation of liberalized technology import policy.

The side arguing for liberalization held an opposite view on the issue of technology import connection. Desai (1985) and Alam (1986, 1987) had taken a view that the

TNCs are willing to part with know-why if the Indian firms are willing to pay for it in terms of costs and duration of agreements. Desai viewed the restrictive technology import policy to be a key reason for the acquisition of shallow technology packages. Alam (1987) emphasised the reason of the existence of non-competitive market environment to be also playing a role in the acquisition of shallow technology packages.

However, it was quite clear that as a whole the side favouring external liberalization of the policy on technology import appeared to rest their case on ample scope the borrowers have in respect of getting deeper and broader packages of imported technology from the foreign collaborations for affecting absorption and adaptation. Therefore, it would be interesting to find out whether the packages obtained by the Indian firms after the liberalization of technology imports have been broad and deep or shallow.

The advocates of liberalisation also argued that the Indian corporate sector is likely to have a better incentive under the policy regime of liberalisation to link itself directly with the structures of publicly funded R&D institutions and academic structures. They believed that the Indian corporate sector would be able to involve the publicly funded RTD structures in the execution of these tasks in a better and cost effective way. They maintained that the tasks of technology acquisition, absorption, improvement and development would get better tackled in an environment of strong competition and removal of controls. They argued for the implementation of stronger patent protection, freedom for collaboration between foreign companies and Indian business for the acquisition of know-how and joint R&D, immediate lifting of controls on internal competition, increased emphasis on export led growth to foster major innovations and public R&D laboratories to be made autonomous market friendly knowledge intensive business services selling organisations (Desai, 1984).

Although they differed in overall terms on the issue of nature and significance of innovations and S&T capabilities created in the different industrial sectors during the period prior to the start of liberalization, but it is also very important to understand that the side arguing against did not have a problem with the argument of lack of large firms. It too considered the proportion of large firms capable of introducing autonomously major innovations being small to be important structural rigidity and causing technological stagnation in the Indian economy. It pointed out that there are structural rigidities functioning in the form of the narrow direction of domestic R&D because it was developing local substitutes for import restricted inputs and materials rather than developing cost effective processes or new products based on local factor endowment or mass consumption demand and much of governmental R&D being not related to the needs of industry and remaining unutilized by industry, a domestic market with low purchasing power and unequal income distribution, etc. It considered small market size to be playing the role of a key barrier to the autonomous introduction of major innovation and as well being responsible for the lack of sufficient technological accumulation and competence building. Therefore, this side was ready to support the goal of higher level of exports through both, domestic efforts and strategic alliances. If the policy changes on trade, investment and technology were aimed at increasing the exports, this side was willing to support the removal of those controls that prevent the emergence of large firms capable of autonomous introduction of major innovations. It is equally important to note that the side arguing

for liberalisation did not totally reject small size of the market as a reason for lack of innovation. The advocates of liberalisation only argued that the argument of small market size does not apply to many sectors of Indian industry because market is fairly large. It seems that these two sides did not really differ so much on the need to go ahead with the policy regime favouring internal liberalisation as much on external liberalization. Their main differences were centred on external liberalization and had a set of diametrically opposite viewpoints on the issue of how the policymakers should be dealing with the problems of protection against imports, protection for small scale industry and domestic firms in general and more specifically with the problems of foreign finance, capital and technology nexus.

Section 2: Post-liberalization corporate technological behaviour and performance

2.1 Internal liberalization and patterns of competence building

In India, the new policy regime of liberalization was implemented in a gradual manner in two distinct phases of internal and external liberalization. During the first phase of internal liberalization, beginning from the mid-eighties onwards up to 1991, the policymakers had largely their thrust on the start of a process of internal competition. With external liberalisation policies still on hold domestic firms were allowed to grow in size and increase their share in the Indian market. During this phase they also had relatively better protection against imports. The policymakers were encouraging the Indian corporate sector to acquire the means of industrial upgrading through technology imports and removal of internal controls[8]. While domestic firms got the government to protect the Indian market from the entry of new foreign firms, in almost all the sectors they made the governments to de-license sufficiently the industrial space, relax the regulations regarding foreign collaborations and foreign exchange and dilute the controls over the expansion of Indian big business to provide themselves with enhanced access to the home market. The government had eased the restrictions in respect of the scope and terms of duration and payments for technology collaborations. The corporate sector was provided with a wide range of fiscal and non-fiscal incentives to take an active part in the strengthening of in-house technological capabilities. It was even encouraged to access the publicly funded R&D institutions for the purpose of consulting them for problem solving and sponsorship of R&D for taking their assistance in the task of absorption of imported technologies.

[8] Starting with the mid-eighties the government undertook these reforms at a fairly good speed for a period of about six to seven years. The Indian corporate sector was freed from the controls of the government over capacity regulation, reservation of markets and access to foreign exchange. Capacity controls were removed more particularly in the sectors of importance to the big business. Selectively several industrial segments were de-reserved and de-licensed for the benefit of their entry. The Monopolies and Restrictive Trade Practices Act was diluted to facilitate the expansion and diversification of large firms or firms belonging to the big business groups. In case of foreign investment regulation the step taken was the grant of automatic approval, or exemption from case by case approval, for equity investment up to 51 percent and for foreign technology agreements in identified high-priority industries. Foreign Exchange Regulation Act was modified so that companies with foreign equity exceeding 40 percent of the total were to be treated on par with foreign companies. However, foreign controlled companies were restrained from having a direct access to the internal markets. Foreign controlled companies were allowed an entry if they fulfilled the obligations of furthering the exports from India or of bringing to the country highly monopolised technologies.

As far as positive outcomes are concerned, they seem to indicate that the sectors of pharmaceutical and automotive industry were the key beneficiaries of the hold put on external liberalization by the policymakers during this phase. But their better performance also confirms that the advocates of external liberalization were far more incorrect than the advocates of internal liberalization regarding their conclusions about the corporate technological behaviour. Empirical outcomes in respect of corporate technological performance contradict quite consistently the theoretical understanding that the advocates of external liberalization had devised to explain the limitations of earlier policy regime. Analysis undertaken also tells us that though pharmaceutical and automotive industries performed better in respect of competence building but their better performance is more of an exception to the rule. Below we discuss how we assess the empirics obtaining concerning corporate technological performance under reforms in relation to the dimension of breadth and depth of imported technology packages.

Experience of the collaboration and in-house technological activity undertaken during the phase of internal liberalisation indicates that as the Indian corporate sector was allowed to import foreign technologies under highly diluted restrictions and without any technological coordination, what actually followed in respect of technological assimilation after the policy change was very different from the initial expectations of policymakers. First, the policy of technology import itself was allowed to become a vehicle for the foreign firms to demand financial participation from the collaborating firms in India. The policy was implemented without any discipline regarding the entry of foreign capital. Under sectional pressures the policy ended up allowing frequently an indiscriminate entry of the foreign capital. Further, though this entry was facilitated by the changes made in the name of technology modernization and improvement, yet there existed no safeguards in the policy of technology import to ensure the import of technological know-how packages with greater breadth and depth. Two, the import of technology by the big business firms was particularly targeted largely to the acquisition of brand names. The packages of know-how that they chose to import were fairly shallow. Third, the changes made in technology import policy have been a facilitator of greater technological fragmentation.

Given below is some of the available evidence for the above-mentioned trends.

During this period there was a major spurt in the activities of foreign collaboration with the west. In India, by the mid-eighties when the new policy period with its bias towards liberalization was ushered in, the former Soviet Union and Eastern Europe were out of the picture altogether in respect of technological alliances. In the early eighties, the country signed annually on an average about 800 collaborations. In 1992 the figure stood at 1520. Cases involving financial participation had increased at a rapid rate. In 1992, the number of cases involving foreign investment was 736. This means that more than fifty percent of the total collaborations approved in 1992 were cases involving foreign investment. Even more significant was the fact that the number of cases involving foreign investment was close to almost double of the figure of total number of collaborations involving foreign investment (385) during the whole decade of seventies. Foreign collaboration agreements reached a figure of about one thousand by the mid-eighties. During 1985-1990 the total number of new agreements approved was 5203. This was 80 percent more than the 2916 approved over the preceding five-year period 1980-1984.

Right from the beginning in the collaboration agreements there was an absence of demand for the increase of technology content in the corporate sector in most industries. From the side of the national enterprise sector there was much interest shown in the import of capital goods and transfer of the advantage of assets like brand names. It would not be wrong to claim that much of the foreign collaboration activity in engineering sectors was motivated for the national enterprise sector by the advantage to be realized by the acquisition of foreign brand names. Gradually there was also much encouragement for the Indian industry to enter into collaborations, which sought the financial participation of foreign partners in the name of acquisition of newer technologies. The stimulus for this new reorientation in the policy was strengthened by the compulsions of increased competition that demanded these types of agreements where the transfer of advantages offered by the acquisition of foreign brand names and foreign partners was the motivation.

There is evidence that there was an absence of demand for real innovation from large parts of the domestic enterprise. This made the purchasers of technology to persist with the import of shallow technology packages. Between 1985-86 and 1990-91 the average technology import payments intensity was as small as 0.21 percent. Firms spent less than 1.1 percent of the sales on technology import. Surveys made showed that firms involving foreign investment were spending less on in-house R&D (Alam 1993).

A number of industrial groups changed themselves to don the new clothes of foreign collaborating firms having hybrid brand names like Wipro-Sun, HPL-HP, Hero-Honda, PSI-Bull, etc. This situation was partly a product of the craze being built by these firms for the foreign brand names. Within this structure the demand for indigenously developed technologies that did not provide the foreign brand names was bound to be low. There was a flood of collaborations for assembly of televisions, two wheelers, cars, etc. Dualistic industrial structures emerged even in the industries that produce standard products such as lamps, soaps matches, etc. For the multinational corporations innovation was not the main means to increase their profits in which they were dominant. They had much more powerful weapons in their hands for increasing their profits, namely supporting their brand name with more advertisement and strengthening their monopolistic trading network. Needless to say, if it were not technology but the brand names contributing to the success of the multinationals in the consumer goods sector, why would such a market generate demand for indigenous technologies? (Menon, 1987)

Evidence is clear that as far as the performance of the older big business groups is concerned they rarely utilised their potential for the development and realization of technological economies during the period of internal liberalization, the market remained fragmented between different type of technologies and sizes. The industries that supplied inputs continued suffering from the problems of market size being smaller that what it actually could be if there was no technological fragmentation. The example of engineering industries is a case in point. Be it the tractor and auto industry developments, or the developments in electronics the problem of technological fragmentation was further compounded. Due to the removal of restrictions on the technology associated imports of capital goods and components there was no possibility of stopping the big business groups from signing the foreign collaborations having clauses that tied them to their respective partners for the import of capital

goods, components and engineering materials. Needless to say, the older big business groups were more interested in the brand names that came with these collaborations.

The situation in the capital goods industry, where the public sector was active, had therefore come to become desperate quite early during this period (Jacobbson & Alam, 1994). Despite the new investments the orders were being placed with foreign suppliers, resulting in the under-utilisation of capacities, which in turn meant the threat to the viability of the very companies. The first causalities were power equipment and machine building for fertilizer industry. This happened in spite of the fact that BHEL equipment had been performing creditably. The sufferings of supply units such as Bharat Heavy Plates and Vessels (BHPV) and Bharat Heavy Electrical Equipment (BHEL) increased during the period in a big way. The machine tools sector had started stagnating. The co-existence of under-utilized capacity in the capital goods industry and utilization of imported equipment was even affecting the design and engineering and consultancy organizations. For example Project Planning and Development India Limited, the premier fertiliser consultancy organisation having capacity to design two fertiliser factories per year, had work for only one factory in 1987, with nothing more in the pipeline. From the above it would not be wrong to conclude that the growth and freedom of the Indian corporate sector were achieved by the Indian state in a way that also weakened the national system of innovation in respect of its autonomous capacity to innovate because the engineering and design capabilities of the capital goods sector were either weakened or lost.

Finally, in conclusion, it would not be incorrect to state on the basis of the above evidence that during the period of internal liberalization itself the industrial structure had undergone a significant change, though not on expected lines. There was an expectation that the big industry would make investments to introduce specialisation and achieve technological dynamism. The claim was that with the removal of capacity restrictions and market entry barriers that were believed to be preventing the big business groups from going for cheap, efficient and dynamic technological change these groups would be able to create technologies for new products, processes and systems not only based on the increased scope for the absorption and adaptation of imported know-how but also based on the development of indigenous R&D. While none of these macro trends could be realised by the big business during the period of internal liberalisation, but the crisis of the economy was at the doorstep. The solution to the crisis of the Indian economy came through the changes in the regime of internal liberalisation.

Evidence also seems to indicate that with the exception of some of the domestic private sector firms in the pharmaceutical and automotive industries in India in most industries the Indian corporate sector had failed to initiate the processes of integration of the ‘latest’ major S&T advances into the productive economy of India in a virtuous way. Introduction of the major innovations was in no way undertaken any better than before. Small size of the market in many sectors had come to appear as a key constraint for the further growth of domestic firms. Finally these reasons only made the Indian big business to clamour, on the one hand for the relaxation of restrictions put on foreign direct investment and technology imports, and on the other for the hastening of the process of privatisation of the Indian public sector

2.2 External liberalization and patterns of corporate technological accumulation

The second phase of policy reforms were introduced amidst the chorus of the voices of there is no alternative (TINA) to external liberalisation[9]. At the end of eighties the perception of pro-liberalisation policymakers was that the Indian government cannot discipline the public sector institutions, and the private sector industry by itself was quite strong to take on the functions of the government in a number of sectors. The big business had a major interest itself in engineering the feeling in favour of further liberalisation. The big business was looking forward to encourage the governments in power to privatise the assets of the private sector. Of course, there were also factors like the changed conditions of post-Soviet world, which did prompt the Indian big business to promote readily the pace of the reforms that have tended to drive the big business to subordinate its own strategic interests in a big way to the foreign capital. In the second phase of reforms the added thrust of policy changes was external liberalisation. There was a massive change in the country's economic and technological environment due to the introduction of economy wide liberalisation of trade and investment. For the Indian corporate sector the policy change of nineties definitely has implied a wide range of new competitive pressures from the foreign companies. Though to cushion the impact of external liberalisation the changes were introduced in a gradual way by the Indian government, but for the Indian corporate sector the changes that this new regime has undoubtedly forced till date are by no means insignificant.

Coming to the consequences for liberalization of technology imports on technological accumulation, the advocates of external liberalization have not been proved again as arguing for an appropriate policy change. During the period of 1990s the trend of decrease in number of independent technical collaborations got even sharper. Those who were only interested in the signing of independent technical collaborations with zero equity or silent financial participation became far and fewer; take the year of 2000 when out of the total of approved collaborations numbering 1248 the number of technical collaborations was mere 231. The situation is no better for technical

[9] First of all, the corporate sector, including foreign companies, was gradually freed completely from the controls used by the government to reserve and regulate their access to the Indian markets. Second, the policy of total freedom to the Indian firms to enter into collaborations of their own choice with the foreign firms was introduced. Over the period of last two decades the policy of greater openness to obtain technology import from the foreign firms has graduated today to the level of the policy of total freedom for foreign direct investment. Third, the policy of higher fiscal incentives and non-fiscal concessions to the corporate sector for undertaking in-house R&D has been considerably strengthened by the government to attract the industry to come forward for the establishment of in-house capabilities for greater innovation. All these concessions have been given with the aim to encourage the enterprise sector to 'innovate' faster in respect of the development of new products and processes and the absorption of imported technological know-how. Fourth, the policy for protection of intellectual property rights has been changed to bestow an absolute monopoly to the generators of intellectual property again with the aim to encourage the corporations to invest in the development of technology in a bigger way. Fifth, there has been a shift in the patterns of regulation of development finance. The new policy regime has moved in the direction of deregulation of the priority lending earlier undertaken actively by the development finance institutions. It encourages the foreign venture capital entities to freely establish their operations in the sectors of their own choice. Sixth, the corporate sector has been offered a strategic role by the government in the processes of policy-making, planning and regulation with the aim to achieve a better level of coordination between the S&T institutions and the Indian industry.

collaborations in the year of 2001. Up to the month of August 2001 out of the total of approved collaborations numbering 1260 the number of technical collaborations was mere 197. During the year 2002 out of 2273 foreign collaborations approved 1958 cases involved foreign investment, which means that there were only 315 (13%) independent technical collaborations signed by the Indian industry.

Further, it also needs to be noted that while there were only 4% majority approvals in 1991, the share increased to almost 16 percent by 1997. The most dramatic change was witnessed by the wholly owned category of firms in the foreign direct investment. The share of subsidiaries was itself seventeen percent by 1997. The government no longer insists on Indian partnership for FDI in most industrial sectors. Merger and acquisition activity grew at an unprecedented rate during the 1990s, rising from US $ 3.5 million to US $ 1 billion by 2001. Many such arrangements were worked out between Indian and foreign firms and the bulk of these involved MNCs. To wrap up this subsection, it is clear that foreign companies have a higher level of control in the Indian Corporate sector than before.

2.3 Impact of the freedom given in respect of imported technologies on exports

Contrary to the expectations of the advocates of liberalization, foreign technology licensors do not want domestic firms to become competitors by providing disembodied technology in high and medium technology sectors. Nagesh Kumar (2003) confirms through his study on the determinants of exports during the period of liberalization that India has not able to acquire foreign technologies for improving export competitiveness. The relationship of foreign technology licensing with export competitiveness was found by him to be negative overall. Favourable effects were found only in case of the low high technology / low technology sectors. This clearly suggests that the advocates of external liberalization were incorrect in suggesting that the liberalization of technology import would allow the large firms to increase the breadth and depth of technology imports to a significant level and benefit major innovations leading to more exports from these firms. It is also clear that at the moment the country has fewer bargaining chips to get the foreign licensors to part with the technology packages that would allow domestic firms to become export competitive on the basis of imported know-how in high-tech manufacturing. This can work to an extent in the case of low technology manufacturing and in services sector where the factors other than knowledge are per se providing competitive advantage to the domestic firms.

This is also further confirmed on account of the results obtaining for the positive role of foreign direct investment. It is well known that prior to the regime of liberalisation foreign ownership or MNC affiliation did not count much in respect of increase in the exports from India. After the introduction of liberalisation foreign ownership / MNC affiliation appeared to have started mattering; in case of the determinant of foreign ownership / MNC affiliation, favourable effect is observable across all technology classes. It seems that the Indian locations are also beginning to be integrated by the foreign firms through the establishment of their affiliates in the sectors like auto and other consumer industries. In the case of information technology services sector, a similar trend is growing. According to NASSCOM, offshore operations of global IT majors accounted for 10-15 per cent of IT services and BPO exports and captive BPO units account for 50 per cent of BPO exports. MNC-owned captive units are scaling

up their operations quite steadily with the headcount forecast to grow by at least 30 per cent this year.

2.4 Performance of liberalization in respect of technology assimilation & in-house R&D and engineering

Technological change is understood in the developing countries in terms of the combined effect of in-house R&D and technology import. We need to go beyond the evidence analysed here regarding the emerging pattern of acquisition of foreign technology and look into the practice of large private sector firms in respect of technological assimilation and in-house R&D to pursue the issue of determinants of technological performance of large private sector firms. An analysis of the recent record of Indian private sector in respect of technological innovation undertaken in the form of case studies by Basant and Chandra (INTECH, 1999) confirms the inadequacy of investments in the manufacturing and quality systems.

BOX 1

PRIVATE SECTOR IN R&D: POST 1991

- **87.4% OF R&D EXPENDITURE IN INDIA IS STILL BORNE BY GOVERNMENT: THE PRIVATE SECTOR IS IN POOR SECOND POSITION.**
- **In house R&D Units have only Risen by 207 units Even 9 Years after Reform Package: (1000 in 1990 to 1207 in 1999).**
- **Private Sector R&D Expenditure is less than 15% of Total R&D Expenditure in India Today amounts to less than 0.1% of Turnover.**
- **R&D Expenditure Declines Between 1994-1995 and 1996-97 from 0.70% to 0.64% of Turnover for Both Public and Private Sectors.**
- **IN CONTRAST DEVELOPED COUNTRIES SPEND 3-4% OF TURNOVER ON R&D: PUBLIC AND PRIVATE INVESTMENT ARE ALMOST EQUAL.**

Typically, acquisition of technology from abroad has been seen as the key element of technology to become competitive. However, indigenous R&D undertaken to assimilate foreign technology and exploit technology spillovers along with access to complementary assets for competitive manufacturing appears to be still missing from the technological conduct of large enterprises. Share of industrial development in total R&D in private sector industry declined from 71.3 % in 1977-78 to 33.9 % in 1996-97 (R&D in Industry, DST).

In the case of Indian Basic Chemical Industry, Narayanan (2004) provides evidence of not only than more than half of the firms in basic chemicals industry are passive but also that higher vertical integration had a negative impact on the technology investments. He also provides evidence that even in the post-liberalization period the medium-sized firms in the Indian Basic Chemicals industry have been investing relatively (to their size) more on R&D than the firms that are larger and smaller sized.

With the withdrawal of policy support to the civilian public sector units whose influence has been significant on the building of indigenous engineering design capabilities the Indian system of innovation will be largely a lame duck; as compared to 50.5 % in private sector 79.2 % of the R&D personnel in public sector report Engineering & Technology as their field of specialisation-RDI, DSIR, October 1999.

It is not prudent to leave the crucial task of building the capabilities for engineering and design to the private investors whose track record is extremely poor in this regard. Whereas take the pattern of employment of engineers in the private sector, they are mostly deployed for marketing and after sales service. Their involvement with the hardcore engineering is limited to detailed engineering work and services. A large part of the engineering sector confirms to the above description of technological behaviour of the large private sector firms. For example, this is true for the IT companies. Software packages represent a tiny proportion of exports. Large amounts of development work take place at the client's site. High skill tasks of analysis and design are left to the client. A lot of work that is confined to low skill software construction and testing work only comes to the laps of the Indian private sector. Large enterprises in the Indian software industry continue to be weak on the development of higher-level software skills.

In order to refurbish the industrial R&D scene, the union budgets starting with 1996-97, 1997-98, 1998-99 to 1999-2000 had even several new incentives to encourage the investments in R&D by industry; however judging from their impact it can be easily seen that there has been hardly any significant change in the growth of private sector R&D activities. Promotional efforts undertaken by the government to lure the corporate sector to participate in the development of indigenous technology have been far from effective. Even today, industrial production based wholly on indigenous R&D does not amount to more than 5% of the total.

2.5 Narrowing of the industrial and product structure and new barriers to major innovation and technological accumulation

A major aspect that needs to be underlined in respect of the dynamics of innovation system is the relation of innovation with the changing industrial structure and economic growth. Freedom that the policy provided in respect of project imports and technology choices to foreign investors appears to have had more adverse consequences than any substantive benefit for a systematic development of the industry. In the sectors like power and telecom which are critical to the process of technological transformation, the policy has led to the under-utilization of local production capacities that the country earlier developed during the phase of pre-liberalization with great sacrifices. Since the beginning of nineties the stated policy of the governments in power has been no restrictions on the foreign direct investment in power, telecom, roads, ports, oil and gas, coal and other non-fuel minerals. Deregulation and opening up have been implemented in the midst of severe constraints put on resource mobilization, an indirect consequence of a changed profligate fiscal policy. Available development funds were refused to the public sector for making investments. The state investments in power, telecom, roads etc., were systematically cut down on the plea of lack of resources while lowering taxes on luxury goods encouraged luxury consumption. The new power policy allows the import of fuel and almost all the private sector proposals made during this period were gas based or based on imported coal. In the earlier policy reliance was on the utilization of domestic coal, which had made Bharat Heavy Electrical Limited (BHEL) to develop boilers that could utilize 40% ash in domestic coal. BHEL, the unique major Indian power plant equipment manufacturer, which has the capacity to manufacture a complete range of equipment for the power market, is a target of the multinationals whose own home markets are today saturated. By resorting to tied-

credits the power multinationals were able to push in their equipment during the period under discussion in many Indian projects.

The capital goods sector was one of the first sectors to undergo reforms in India. It is now well known that this sector has been affected adversely. The specific technological characteristics of the industry raise serious doubts about the ability to develop capability in the context of uncontrolled liberalization. The capital goods industry is in deep trouble because of the policy of liberalization, which allows the downstream industry to import capital goods unquestioningly. For the capital goods sector sectoral growth rate shrank from 15.24 during 85-91 to 5.27% during 91-97. Imports rose phenomenally faster during the period of 91-96 as compared to the period of 80-91. Since mid-1990s with liberalization measures like reduction in tariff rates and liberal import of second hand machinery there has been a serious adverse impact on the health of the machine building industry. Electrical machinery sub-sector registered a fall from 25.34% to 6.3%. Imports rose even faster during 91-96 as compared to the period of 80-91. While the related figure for imports was 21%, exports share remained at 6%. There was a large inflow of foreign technologies into the capital goods sector during 91-97. The share of non-electrical machinery in the value of output in registered manufacturing increased somewhat under controlled liberalization during the eighties but it has since decreased in the 1990s. In 1997-98 the share of non-electrical machinery (at 1993-94 prices) was 4.8%-the same as its share in 1965-66 (shares of non-electrical machinery, tools and parts are taken from M. Padma Suresh 2004).

In the case of the machine-building sector, there is no evidence of a gradual building of capabilities leading to exports and outward orientation in investment. The contribution of the non-electrical machinery sector to exports remains poor. Exports of non-electrical machinery as percent of exports increased from 0.47% in 1960-61 to 1.85% in 1970-71 and further to 3.2% in 1980-81. The figure has remained more or less the same since then with the share being 3.41% in 1999-00. Imports of non-electrical machinery are higher and as percent of total imports were 6.05% in 1999-00. During the period of liberalization, in the case of capital goods industry, the performance in respect of R&D investment has been highly disappointing. R&D investment was very low (Ministry of Finance, 97-98). In the case of machine tools industry, a recent survey also confirms that though during the period of liberalization foreign collaboration approvals significantly increased the average R&D expenditure for the studied sample of firms remain till date less than 2%. Accounting for about 0% of net sales imports of raw materials and components are till date significant.

In electronics industry, an immediate impact of the liberal policies of eighties was an unprecedented shift in the product structure. The growth became concentrated in sectors with higher linkages in terms of imports, whereas sectors with higher linkage in terms of value added and employment lagged behind in output growth. The component sector remained characterized by the lack of investment coupled with low scale of operation and under utilization of capacity. By the end of 1980s the share of semiconductor industry in total electronics investment in India was around 10 percent as compared to the figure of 30 to 35 percent in the developed countries. There was a marked increase in the share of electronic consumer products at the cost of electronic intermediates and electronic capital goods. However, in case of computers, due to the controlled nature of internal liberalization it did become possible to make the foreign

companies that had preferred exit to sharing equity with local firms in the 1970s to enter into joint ventures with the Indian partners. The absence of a strategic approach to the strengthening of international competitiveness is even more sharply reflected in the nineties. During the decade of nineties, the share of communication equipment experienced a marked decline. The production of data processing equipment was not able to keep pace with the ongoing IT trajectory and their share in total output remained stagnant or declined. In the case of electronic intermediates, not only their share declined over the years but also components incorporating higher level of technology like the semiconductor devices recorded a sharp decline. It is to be underlined that even after the introduction of liberalization there has been an increase in the number of products, which recorded high production growth but low export intensity.

2.6 MNEs get entrenched deeper in the productive and R&D structure

In an industry consisting of a variety of firms that differ in terms of their access to technology, knowledge and other intangible assets, liberalization would certainly result in gainers and losers and the productivity gap between firms in an industry could widen. However, from the perspective of understanding the relation between technology diffusion and liberalization, it is still relevant to check out whether the average productivity levels of an industry have increased or decreased during the post-liberalization period. In his introduction to a recently published Special issue of Economic and Political Weekly Siddarthan 2004 sums up the evidence becoming available with respect to the impact of liberalization on productivity, technical efficiency and growth. In concluding, his summing up suggests quite clearly that the studies undertaken by the scholars associated with the Institute of Economic Growth (IEG) do not support the hypothesis relating to an increase in productivity / efficiency in Indian industries consequent upon economic liberalization. Siddarthan 2004 reports that the total factor productivity (TFP) growth in the 1990s was lower than in the 1980s. Siddarthan (2004) also concludes the results of their studies by stating that a) the main gainers have been MNEs and their affiliates which have better access to technology and other intangible assets, b) in the case of domestic firms those who have adopted a strategy of relying on non-equity route for technology imports against royalty payments are alone reported to have done well and c) the other domestic firms that have no networking or non-equity strategic alliances have not done well. Further, that in the case of domestic firms only when their technology and productivity gap was small in relation to MNEs they have done well under liberalization.

2.7 Gains in industries benefiting from calibrated protection during the same period

Take the cases of automobile and pharmaceutical industries, which have gained maximum in terms of the competitiveness of domestic firms and the building of competence during the period of last two decades. Both were beneficiaries of the policy of calibrated protection that the governments pursued to steer and nurture them throughout the period of eighties and nineties. External liberalization was put on hold till the beginning of twenty first century. The government insisted on the phased manufacturing programmes and partnership with Indian firms while allowing technology imports and foreign direct investments. Public sector firms were used to create the capabilities that have spun off individuals who have come into private sector and have benefited both the industries in terms of human resources needed for building competitiveness in both domestic market as well as export markets.

Automobile industry

In the case of automobile industry, the decade of eighties introduced internal competition through broadbanding and calibrated foreign collaborations in car, commercial vehicles and two wheeler segments, introducing products that are considered to be technologically superior within the market. Of the total 182 foreign collaborations approvals for the auto sector during 1982-91, as reported by Narayana and Joseph (1993), roughly 20% were financial, 70% pure technical and 10% design and drawing agreements; the number of collaborations were 32 and 150 for vehicle and component sectors. Apart from technical agreements with global majors, there were joint ventures with Japanese original equipment manufacturers (OEMs)-referred to as the 'Japanisation' phase (ACMA & SIAM, 2003). In the car segment the Govt. of India –Suzuki JV, Maruti Udyog Limited (MUL) was set up; however, in the 1980s the government restricted entry, having anti-competitive implications. Of which, the sections within industry were quite critical. For the car and multi utility vehicles (MUVs) segments the 1990s represent, first of all, the entry of Indian private players Tata Motors (then TELCO) and Mahindra and Mahindra (M&M).

Only from the mid-nineties many global players entered, mostly proposing initially to only assemble imported SKD / CKD kits (Auto Policy, 2002).). For the balance of payments reason, the government in 1995 asked these companies to individually commit to an equivalent amount of exports (ICRA, 2003b). Although the policy of uncontrolled external liberalisation was gradually creeping in through the weakening of performance requirements, but due to the influence of strong local interests the 1997 Auto Policy still required establishment of production facilities, not just assembly operations. Moreover, a new manufacturer of cars or MUVs had to commit by signing an Memorandum of Understanding (MOU) to achieve a minimum indigenisation of 50% by the 3rd year and 70% by the fifth year of the firm's first consignment of CKD / SKD imports; and to commit to an equivalent value of total exports of vehicles and components, starting the third year of production, neutralising the foreign exchange spent on CKD / SKD imports during the currency of the MOU. Also for having operations as a subsidiary, new foreign entrants had to bring in at least $50 million. Eleven companies signed such MOUs with the government (auto Policy 2002). From April 1, 2001, quantitative restrictions (QRs) were removed; SKD / CKD and even completely built units (CBUs) imports of cars were put on the open general license (OGL) list, not requiring an import license any more; as announced in Jan. 2000, the foreign exchange neutrality requirement was lifted for new investors. The export commitments made under the MOU regime were abolished in August 2002.

Through the newly announced Auto Policy, 2002 the policy makers seek to establish a globally competitive auto industry in India-emerging as a global source of auto components and an Asian hub for export of small cars-and to double its contribution to the economy by 2010. Although it is a big shift away from the earlier goal of encouraging the local manufacturing base for the development of autonomous Indian Auto industry coexisting the global majors in India, but consistent with the expectations of this paper it is not at all surprising that this shift has come about in 2002[10]. However, as per the theoretical framework of this paper it is not difficult to

[10] Even earlier on account of the implementation of performance requirements the policy was compromised several times under pressure from the global majors. The incidences of explicit

foresee from the patterns of technology collaborations, alliances and MNCs entry for the auto industry that in particular after 2002 the impact would not be beneficial for the process of technological accumulation from the point of view of peoples' needs. Neelam Singh (2004) also confirms this on the basis of her survey of the automobile industry. Higher 'input import' as well as 'tech import' propensities and a lower R&D intensity of foreign affiliates are observable from her survey results[11].

In the area of Auto R&D, there is the emergence of the trend of foreign firms like GM, Ford, Suzuki and Hyundai already choosing India for the outsourcing of engineering and design services. GM, Suzuki (Maruti) and Hyundai are starting R&D bases in India. Suzuki has decided to develop India as its only R&D hub for small cars in Asia outside Japan. GM's engineering centre to develop automotive electronics and control systems and Ford's software development centre in India would cater to their Asian operations. However, these trends have to be read along with the fact that the R&D intensity of Auto Components segment is still low. The R&D spending is still small-0.3% average R&D intensity during 2001-02 and 2002-03 (Neelam Singh 2004). Among the Auto components producers the trend is towards international business, not exports alone. In recent years Amtek Auto, Sundaram Fasteners Ltd and Bharat Forge have acquired firms in US, UK and Germany to supply to global OEMs captive base.

---

performance requirements have been low for both the vehicles (+ engines) and components sectors. The performance requirements have been primarily as export obligations (EOs) and during the early period as a few cases of phased manufacturing plans (PMP) / import restrictions. The R&D and technology transfer requirements are few and rather trivial. There are no cases of 'training of approvals technical collaborations for vehicles there is one each case of 'no import of (none financial) faced any performance requirements; among employees' requirements. For the vehicles or engine manufacturing, during 1984, 1988 and 1991 only 7 foreign collaboration capital goods' allowed and 'prototype of the vehicle to be tested by a specified institute', loosely speaking, a case of technology transfer requirement. The 1992 to 1993 data list no performance requirements, except for a '50% FE' vehicle firm to produce the latest models, a kind of technology transfer condition. A similar case is found during 1995 to 1997; additionally this firm faced EO and PMP requirements (and an explicit dividend balancing requirement). The 1998 to 2000 period is devoid of any explicit performance requirements. For the component sector, during '1984, 1988 and 1991' period, 3 technical collaborations faced R&D obligations (all for1984), simply as having an in-house R&D facilities / program; a majority foreign collaboration was allowed import of capital goods only against foreign equity; post-1991, the imposition of performance requirements has been minimal, only a few cases of 100 (or 75%) export obligations (Eos) in the form of special cases. These are export-oriented units that have been taking an advantage of several associated benefits in export processing zones. Her results also confirm that while the MOUs and export related commitments contributed positively to the development of local manufacturing base and ancillary development, the latter developments of late nineties of no or weak performance requirements, permission for 100% FE, no minimum investment criteria specified for FDI, etc. did not seem to encourage value addition to the earlier extent.

[11] At present in India in the vehicle sector there are very few joint ventures. For the car segment, in general, the local partner's equity stake has been reduced to zero or an ineffective negligible level. The new 4-wheeler premium models are being introduced by MNEs in India almost invariably as CBUs or as CKDs, and the localization of their intermediates is expected to be slow. The earlier achieved high degree of overall indigenisation of vehicle manufacturers is expected to fall for many firms. For the new vehicle models introduced in India by foreign affiliates, we are witness to the problem of high import dependence. The re-alignments of joint ventures has also taken place in the auto components sector, some technical collaborations have been turned into financial ones. As part of global mandating, though foreign automobile MNEs are likely to outsource increasingly some type of components through their affiliates / tie-ups here, yet it is to be kept in view that the increased export-output ratio of the auto component industry would be taking place as a part of their global integration strategy.

With the latest policy initiative (SIAM, September 2006) of the auto industry in which the government is a partner the global vision outlined strengthens the trends of global integration further. The Indian auto manufacturing is being integrated into an international division of labour where the domestic players from both automobile components segment as well as auto assemblers segment are also expected to internationalise their production system. While India is certainly going to be utilized as a manufacturing node, but whether this would allow the national system to leverage this initiative for the benefit of Indian transport system needs is an important policy issue for the policymakers dealing with STI promotion.

Pharmaceutical industry

In the case of pharmaceutical industry, right through the eighties and till very late in the nineties the policy of sectoral reservation was in operation benefiting the domestic firms to grow in respect of capabilities for the production of generics. The strategy of export of generics is today providing quite a few of the large domestic firms over fifty percent of their sales turnover. In promoting the domestic generic industry, the Patent Act of 1970, which did not allow product patents in the area of pharmaceuticals, was a key instrument of calibrated protection. In India, it benefited the domestic firms a lot because the government combined the patent act with sectoral reservation, a key element in the drug policy of 1978.

Under the Indian Patent Act, 1970 the country was free to develop alternate processes for the drugs that were still under product patent protection (on-patent drugs) in the developed countries. Several domestic firms came on the local market scene during the decade of eighties using the technologies for alternate processes developed in-house and by the CSIR laboratories. In the process, the CSIR got an opportunity to contribute to process chemistry and has over fifty new chemical reactions to her credit today. This shows that with the instruments of calibrated protection in place the industry and research institutions got a chance to contribute to science and technology in generic terms. In this context, it would not be incorrect to point out that the advocates of liberalization characterized the R&D work undertaken by the CSIR and industry as reinventing the wheel and an unnecessary costly incremental minor innovation.

With the implementation of the drug policy of 1978 the Indian Government had an effective public policy package consisting of sectoral reservation, incentives for the production of bulk drugs from basic stage, restrictions on FDI, etc., introduced for the benefit of the domestic pharmaceutical firms, which was in place till the early nineties. This package could enable the firms that had not been built by the big business but by the technical entrepreneurs to operate successfully to beat the barriers being erected by the multinational corporations in the Indian markets through their advertising investments and construction of the sales and distribution networks. These firms got an opportunity to emerge as the viable suppliers of many of these drugs in the local Indian market. Today these firms are leaders in the domestic market. It would not be therefore wrong to state that their emergence and consolidation is a result of the support that these firms got from the state in the form of protection through the patent legislation, sectoral reservation, price regulation protection, supply of talent developed within the public sector and publicly funded R&D support (Abrol,

1994). The advocates of liberalization were opposed to all of these measures. Thanks to the alternative framework of building the industry as a development block India was able to nurture the child of the state, which is again going awry because of the policy of external liberalization and deregulation being put in place since the mid nineties in India.

2.7 Patterns of technology accumulation, innovation and peoples' needs

Now to relate the patterns of technological accumulation and innovation to the satisfaction of peoples' needs, we will take again the cases of integration of Indian automobile and pharmaceutical industries to show how a distorted pattern of technological development is evolving on account of the absence of technological coordination and regulation of the new big business groups. The rules of market governance prevail and determine the S&T priorities.

Automobile industry

On account of the policy of calibrated protection that the governments followed till very recently, India has been to develop a number of producers of components and some engine producers satisfying the international standards. The important question is that whether the network organisers from among the domestic firms would be able to bootstrap themselves technologically at the required pace. Vehicle manufacturers are moving into completely new raw materials and technologies, partly guided by environmental legislation. Supply chain is expected to be affected quite significantly by alternatives to all steel body, electric and hybrid power-trains, electronic control technologies, computerized engine control, on-board diagnostic, intelligent cruise control global navigation and satellite tracking systems. Two-wheeler firms are switching to the use of electronic fuel injection systems and four-stroke engines. Auto research is now focusing on alternatives to the internal combustion engine; the major areas of research are alternative fuels, electric vehicles and hybrid vehicles.

It is not clear that whether in this new paradigm shift for what all segments the Indian Auto Assemblers would be able to position themselves as network organisers to dictate the technological directions. No major firm in India is presently working on fuel cells for scooters-a major auto segment for India. Similarly, the Indian firms are yet to accept the challenge of Euro IV norms in the car segment. Even while recognizing the merit of such moves, the Auto Fuel Policy has essentially stayed away from recommending fuel economy regulations. It instead settled for a mandatory voluntary declaration of fuel economy for each model "to enable informed customer choice.

The fact that such voluntary measures are not sufficient to sober intoxicating gas guzzling on Indian roads came to sharper focus recently when the Madras School of Economics and the National Institute of Public Finance and Policy submitted a report to the environment ministry proposing, 'Taxes on Polluting Inputs and Outputs'. This report exposed how close we are to a worsening fuel economy. As of today, a large number of car models fall in the fuel economy range of 12-16 km/litre and their engine capacity ranges from 796 cc to 1800 cc, with most models in the 796 cc to 1400 cc range. But already a dramatic shift is evident towards mid engine capacity, a trend that is expected to only accelerate in the medium term. The 1000-1700 cc

segment is likely to dominate the Indian car market – already the combined share of the total sales in this segment has increased from 44.5 per cent in 2001 to 63.3 per cent in 2003.

For the Indian legislative and policymaking bodies pushing for fuel-efficient vehicle technology, controlling gas-guzzlers on road, or reducing vehicles miles travelled are not even on the agenda. The August 2004 report of the Parliamentary Standing Committee on Petroleum and Natural Gas considers ethanol blends, driver-training programmes, and upgrading the garages of state public transport undertakings to improve fleet maintenance, as sufficient to conserve oil in the road transport sector. Even the recently-released, 'India's Initial National Communication', drawn up by the ministry of environment and forests for the UNFCCC, as part of the government's self-reporting on its efforts to lower carbon and energy intensity of the Indian economy, indulges only in cosmetic claims – we follow Euro II in some cities that is more energy efficient. The Centre for Science and Environment (CSE, 2004) writes in its latest brief that resting the roost is the Indian automobile industry, happy with the knowledge that it contributes 4.5 per cent to India's GDP. It forgets to calculate the cost to the nation on account of not committing to a combined target of improving fuel economy and lowering emissions significantly.

Indian cities in the grip of rapid motorisation and with cheap diesel prices are headed for the most harmful dieselisation of small car segment ever. Successive stages of European standards, though tighter, are still lenient on diesel. Diesel vehicles are legally allowed to emit more NOx and PM compared to petrol vehicles – and this is the most serious of our worries. Euro II norms allow diesel cars to emit 40 percent more nitrogen oxides and hydrocarbon than the corresponding petrol cars. Even Euro IV norms allow diesel cars to emit 3 times more NOx than petrol counterpart. Instead of following Europe's mistakes loyally, India must skip to avoid them quickly.

It is quite clear that in the case of Auto industry the policy for industrial development needs an immediate integration with the introduction of appropriate auto emissions and fuels policy. Neither the policymakers nor the industry are ready as yet. However, under the policy of liberalisation the patterns of technological accumulation are becoming integrated with either the strategic behaviour of global majors or with the much less autonomous behaviour of Indian Auto firms who are also increasingly getting sucked into the patterns of global integration. The above discussion on auto industry makes to us one fact quite clear that the policy of competition and deregulation are in no way an answer to the introduction of appropriate innovation interventions and practice.

Pharmaceutical industry

After the announcement of the Indian government to discuss the issue of norms and standards of the TRIPs Agreement as a part of the package to be arrived at in the GATT negotiations in 1990 and subsequent implementation of the TRIPS Agreement from 1995 there has occurred once again a major change in the conditions of competition or rivalry in the Indian pharmaceutical industry. First of all, for the multinational corporations (MNCs), which were so far losing the initiative to the domestic pharmaceutical firms in India, major opportunities are now available to them to grow again in both on and off-patent drugs. They have been freed from the

restrictions placed on them by the earlier drug policy of 1978. For example, the earlier policy had prevented them from entering in to the market as subsidiaries or branches if they did not choose to produce the bulk drug from the basic stage. Now this restriction has been withdrawn, and the multinational corporations are totally free to restructure their operations in India. Back with this freedom these companies are now under no obligation to produce the bulk drugs from the basic stage locally. As far as the supply of on-patent drugs after the implementation of TRIPS is concerned, there has been an expectation that rather than coming forward to locate the production of newer drugs in India the MNCs would like to import the on-patent drugs for the Indian market (Pharmabiz, 2000)[12]. Further, as over the years the import content of bulk drugs in the country (which is really technology intensive, as opposed to manufacture of formulations) has also shown a rising trend (in terms of imports of bulk drugs as percent of total availability (in Rs. 10 million) already stands at 50 percent) concerns with regard to the emerging level of competitiveness of the Indian pharmaceutical industry for the new products are required to be assessed by the policymakers.

It is not only the MNCs that have increased the imports the domestic formulators are even resorting to imports. Therefore, several small-scale units in the Indian bulk drug industry are facing a serious threat to their existence[13]. The bulk drug units without a formulation activity on their own, have been under tremendous pressure of price war in the domestic market, which has forced them to get into either exports where the global quality standards are to be met or quitting the business once for all. The abundant supply, low demand from domestic formulation companies for the local made drugs and dumping of imported drugs have together contributed to this chaotic market situation and the result is uncertainty in the industry[14] (Pharmabiz, 2002).

Evidence is growing in favour of the fact that in the immediate future, Indian pharmaceutical firms are increasingly looking for such tie-ups where their domestic facilities will be used for outsourcing of both R&D and manufacture rather than for serving the domestic market based needs of essential medicines. Indian companies are looking forward to leverage upon the advantages of cheap manufacturing and R&D costs to build their linkages with MNCs. They are interested to concentrate on the task of upgrading for entry into large Northern generic markets. They have little interest in satisfying the domestic markets of essential medicines within the country. It is true that it is not possible for the domestic firms to continue anymore their expansion using the earlier route to growth in the Indian market. Large domestic firms like the Ranabaxy, Dr. Reddy's Laboratories, Wockhardt, Sun Pharma, Cadilla, Cipla, Lupin and some others have made the choice of arriving in the global market as a major

[12] Inexpensive or monopoly imports of finished formulations are rising in menacing proportions into India, forcing even the leading domestic drug companies to concede that the threat of import liberalization under WTO is for real in this knowledge-based. Formulation imports by drug MNCs touch Rs 900 cr in 9 months; Eli Lilly and Novartis exceed Rs 40 cr sale each in one product December 11, 2000

[13] The industry also alleges that though the imports of bulk drugs through official channel have slowed down in the past 2-3 years, the dumping and smuggling of drugs are rampant at present. This also has caused huge price discounts in the domestic market. (News archive of Pharmabiz, 2001

[14] Domestic pharmaceutical industry output is expected to exceed Rs 260 billion in the financial year 2002. The bulk drugs will account for only Rs 54 billion i.e. 21 per cent and formulations the remaining Rs 210 billion with 79 per cent. However, the exports of Pharmaceuticals continue to grow especially in the bulk drug segment on account of the emergence of contract manufacturing.

source of exports of off-patent generic drugs (in the form of formulations) to the markets of developed world. During the post-TRIPS period as a result a trend is also on the rise to show that the balance of trade in pharma sector is now becoming favourable. The Indian industry is shown to be therefore in good health (Aggarwal, A, 2004).

To come to the patterns of investment by MNCs, the newer investments of MNCs were largely for the expansion of formulation activity. Newer investments in the bulk drug were few and far between. Further, we expect the post-2005 situation to create certainly far more permissive environment for imports, for a larger number of product segments pharmaceutical MNCs would have increased operating freedom to shift to import based production. Their preference for the establishment of new operations through the incorporation of wholly owned subsidiaries is also a key feature of the new situation.

Quite a large part of the new FDI in pharmaceuticals has been devoted for the benefit of mergers, acquisitions and takeovers to facilitate the parent firms to increase their control over the operations located in India. Global mergers have affected the foreign pharmaceutical industry on familiar lines. Stronger control over the ownership of investments continues to be the main driver of merger and acquisition activity for the pharmaceutical MNCs in India. The government has been made to relax its laws with regard to the control of foreign direct investment. For example, earlier the Indian government used to grant permission for the establishment of 100% wholly own subsidiaries only on the condition that the industry would be willing to take up the production of pharmaceuticals right from the basic stage of manufacture of bulk drugs involved. This is no longer a requirement; it shows that the foreign pharmaceutical firms have been able to improve their bargaining position to a considerable extent after the introduction of TRIPs.

The claimed benefit of increased technology transfer is also yet to accrue to the domestic pharmaceutical firms. Narsalay (2000) shows that during 1991-99 the total number of technical collaboration approvals in the pharmaceutical industry were 187, which formed 3.1 percent of all the technical collaboration agreements approved during this period. For a high technology sector like pharmaceuticals it is quite a low figure. In the industry, however, there is an expectation that the number of technical collaborations will increase only when a product patent regime comes into place in 2005. Dhar and Rao (2002) suggest that so far foreign technical collaborations have not been important for export; they conjecture that only many small and medium scale firms have entered into collaborations with foreign firms mostly to cater to the domestic market. Nevertheless, it is still true that in India like everywhere the full-blown impact of TRIPs Agreement on technology transfer and FDI quality in the pharmaceutical industry is yet to take shape.

Most analysts are also of the view that the Agreement on TRIPs has not been able to succeed in inducing the foreign firms to take up more of overseas R&D in the developing countries. Upadhyay, Ray and Basu (2002) indicate the same about the composition of R&D on the basis of a survey undertaken for the Department of Science and Technology; they suggest that generally R&D activities undertaken by subsidiaries of MNC are minimal. Whatever little R&D they undertake, relatively more thrust is placed by them on formulation R&D (or product development)

compared to bulk drug R&D (or process development). Some adaptive R&D is there for trouble-shooting. Their focus is on conventional dosage forms. Although few of them manufacture novel drug delivery system, no research on NDDS is undertaken at the subsidiaries.

In those cases where some MNCs had located part of their global R&D outfit in India, activities have been on the decline. Barring Hoechst and Astra, who do limited drug discovery work here, others have closed down the units. Earlier Ciba-Geigy had larger presence in R&D; its R&D centre is now closed in India. Hoechst has also been reducing its involvement in R&D in India. Their current strategy is to reduce the local in-house R&D investment in India and build on the work already done on natural products in Europe. Current expectations are that the MNCs will prefer to selectively invest in those R&D operations like bioinformatics and clinical research where by relocation it is possible for them to cut down the R&D costs without increasing information spillovers. Available evidence from India suggests that in many cases the MNCs appear to have preferred the route of outsourcing of R&D from fully dedicated companies to reduce costs in respect of clinical trials and bioinformatics related R&D work. Presently only for the healthcare management and pharmaceutical services the choice of MNCs has been to establish fully owned R&D subsidiaries. Establishment of operations for the implementation of clinical trials, data management and bio-statistics by Quintiles, a leading pharmaceutical service provider, is an example.

Looking at the domestic sector today, only a handful of firms have been able to increase their R&D investments. The budgetary increase is of the order of about 1-2% of sales to 5-6% of sales in the past few years. However, it may also be mentioned that the big business groups do not want to engage in autonomous drug development activity and is interested in selling its rights to the partners abroad for the reason that it does not have the capacity to invest further and stopping after the stage of drug discovery work. Nevertheless, all the developments that we see in respect of the development of drug discovery capabilities within the Indian firms are largely directed to the needs of the western markets today. However, the question is even if the TRIPs Agreement is going to take these firms into largely the direction of undertaking production and innovation for the lifestyle disease oriented markets, but can we expect the locally bred Indian firms to participate competitively in the exercise of independent pharmaceutical innovation. This is mainly because given their present scales as well as the size of domestic markets where they are embedded, locally bred firms of developing countries, are certainly not capable of moving independently in respect of the lifestyle diseases in the western markets.

The factor of small size of market continues to be a constraint for the domestic pharmaceutical firms, in addition they are being blocked everywhere by the MNCs. Strong IPRs remain one of the most important institutional change of last decade that the Indian policymakers can expect to come in the way of local companies. Their adverse effect on the size of market for local firms has to be suitably alleviated. Markets for knowledge and technology are by no means neutral space; policy interventions for industrial upgrading have to take in to account that there is an international division of labour being constituted through the route of outsourcing. Since the latest trap is to get the domestic firms to accept the role of junior partners in the new game of protemics and genomics based innovation wherein the R&D platform / tools are already monopolised via the route of strong IPRs, the patent law

should be suitably formulated to provide space for R&D suited to local needs. In addition, it seems that prospects for domestic R&D for the benefit of Indian people as a whole would improve only under the conditions where the constraint of market size has been suitably eased for the benefit of local pharmaceutical firms through the increase in health expenditure. In the recent period the health expenditure has been declining across the board in India. This is a direct consequence of the implementation of neo-liberal fiscal strategy.

The case of Indian pharmaceutical industry is quite instructive. It has been identified as an island of efficiency by the policymakers in the S&T sphere. It is the new big business groups that are technologically specialised in the pharmaceutical industry. But even their development under the rules of market governance shows that the policy of competition (instead read rivalry) and deregulation are in no way of any help if the country wants to realize the appropriate health goals and patterns of technological accumulation. Domestic firms have been getting incentivised for inappropriate product targets and cannot be made to enhance their efforts on the real Indian needs. There exists an experience of the worldwide practice of wasteful 'negative' innovation emanating from the pharmaceutical sector under the strategy of 'innovation for profit'. In particular, the Indian policymakers have a social responsibility to use the instruments of public sector R&D and governmental support for innovation to the private sector in a targeted way to ensure that the institutions of health sciences remain geared to producing more of public goods rather than market goods.

Section 3 Influence on the orientation and character of national level S&T

3.1 Consequences for the publicly-funded RTD structures

During the period of reforms, if we compare the trend of the national R&D expenditure with the world trend the performance of national RTD structures was highly disappointing in India[15]. But what is equally important to note that much of the enhanced allocations went to the departments relating to defense, nuclear energy and space. Civilian R&D priorities continue to be neglected. Be the state sector R&D or the user departments R&D their allocations have been made to suffer. There has been virtually no increase in the user department allocations. The annual budget on R&D relating to health, communicable disease control, nutrition and family welfare put together is only around Rs. 3500 million. Compare this figure with the spending of Rs. 25000 million for defence R&D and Rs. 8000 million on atomic energy R&D. R&D in meteorology, an area that is critical to agriculture, irigation, flood control, drinking water and disaster prediction is only about Rs. 1300 million. Put together even today the outlays for botanical and Zoological surveys (that are responsible for biodiversity assessment and protection in the country) are of order of merely Rs. 300 million. In 1974-79 the combined outlays to atomic energy and space were 18% of total (Rs. 3000 million). Indian Council of Agricultural Research (ICAR) and Council of Scientific and Industrial Research (CSIR) together came also to the same level of allocation. Today the atomic energy and space are receiving around 35% of total S&T budget. The share of agencies of ICAR & CSIR in total S&T allocation has fallen to around 22%.

[15] The national R&D expenditure as a proportion of GNP rose for the world from 1.85 percent in 1980 to 2.5 percent in 1990s. The proportion of national resources spent on R&D by India declined steadily from a peak of 0.91 percent in 1986-87 to 0.71 in 1995-96. Although under the last government the ratio has increased back to 0.81 percent in 1998-99 (Government of India, 2002).

Publicly funded R&D institutions continue to account for the bulk of R&D expenditure in India with industry spending only 28 percent of national R&D expenditure. The decline in the proportion of national R&D expenditure was mainly due to the budgetary squeeze. Even the rate of growth of R&D expenditure in industry declined in the 1990s compared to the 1980s. R&D expenditure fell in 12 out of 28 broad industries in the 1990s and even where it rose, the R&D to sales ratios stagnated or declined.

Industrial Research and Development Expenditure in (10 million Rupees) and Its Percentage of Sales Turnover in brackets for leading industry groups

Industry Group	1994-95	1995-96	1996-97	1997-989	1998-99
Electricals & Electronics	128.86 (0.6)	136.10 (0.6)	185.60 (0.28)	204.06 (0.30)	200.03 (0.29)
Defense Industries	79.48 (1.9)	79.85 (1.7)	144.79 (4.44)	180.23 (5.22)	218 (6.11)
Metallurgical Industries	51.79 (0.2)	51.75 (0.2)	123.95 (0.48)	123.16 (0.57)	142.56 (0.78)
Drugs & Pharmaceuticals	165.81 (0.4)	198.73 (0.4)	266.34 (0.63)	287.49 (0.63)	377.50 (0.76)
Transportation	170.42 (0.9)	226.88 (1.0)	133.11 (0.47)	201.15 (0.79)	152.83 (0.60)
Fuels	81.33 (0.1)	106.02 (0.1)	110.66 (0.11)	99.20 (0.09)	156.68 (0.13)
Chemicals (other than fertilisers)	243.46 (0.8)	309.16 (0.8)	180.49 (0.51)	174.67 (0.47)	195.14 (0.51)

Source: Department of Science & Technology

3.2 Shaping of the publicly funded civilian industrial research

Take the example of the Council of Scientific & Industrial Research-the largest civilian R&D agency of India. Goals set for the year of 2001 were to move towards the path of self financing by generating over Rs.7 billion from external sources, as against Rs.1.35 billion in 1994-95, of which at least 50% will be from industrial customers (up from 15% in 1994-95); develop at least ten exclusive and globally competitive technologies in niche areas; hold a patent bank of 500 foreign patents (up from 50); realize 10% of operational expenditure from intellectual property licensing (up from < 1%); and derive annual earnings of $ 40 million from overseas R&D work and services (up from < $ 2 million).

Over two-thirds of the council's income continued to come from budgetary support. External cash flows continued to account for only about one fifth and this has remained more or less around the same level over the period of last one and half decade. Government (budgetary support plus contract revenue from government agencies as grants-in-aid) continued to be the major source of finance accounting for over 80 percent. The amount of cash generated from the industry continued to about 25 percent of the external cash flows (or about 6 percent of total receipts) and that too has not shown much variation across the years. Foreign earnings do not work out to be more than 1.7 per cent.

The vision 2001 envisaged that CSIR would hold a valuable portfolio of at least 1000 Indian patents and 500 foreign patents. It is well known that the propensity to patent

also differs considerably among R&D organizations and inventors. However, the policymakers were insistent to get the CSIR as a whole to be measured by patenting activity. The Council has been successful in securing 591 Indian patents and 101 foreign ones cumulatively (CSIR, 2001). Available evidence also tells us that much of it is accounted for by a select set of five laboratories.

The 'Big Five' CSIR Laboratories based on performance during 1999-02 for patents filed and granted abroad (Source: IPMD, CSIR)

CSIR Laboratories	Filed 1999-00	Granted 1999-00	Filed 2000-01	Granted 2000-01	Filed 2001-02	Granted 2001-02
CIMAP	68	1	38	7	31	25
IICT	32	6	72	4	92	17
NCL	18	12	63	16	43	16
CDRI	16	0	8	6	27	6
IICB	3	1	18	0	9	5
Total-CSIR	199	35	452	56	580	86

Poor CSIR performers from 1999-2002, for patents granted abroad

Name of the Laboratory	Granted 1999-2000	Granted 2000-2001	Granted 2001-02	
CBRI	0	0	0	
CCMB	0	1	0	
CEERI	0	0	1	
CMRI	0	1	0	
CSIO	0	0	0	
CSMCRI	0	0	0	
IMT	0	1	0	
NAL	0	0	0	
NBRI	0	0	1	
NGRI	0	0	0	
NIO	0	0	0	
NML	0	0	0	
RRL (BHU)	0	0	0	
RRL (BHO)	0	0	0	
RRL (JM)	0	0	0	

Gupta (2004) has analysed the whole count data of Indian patent output of 2880 (1978-2000) inventors who produced 6877 patents in India. Of these, 62 (2%) inventors produced 1225 patents (18%) patents, 691 (24%) inventors produced 4166 (61%) patents and 2189 (76%) inventors produced only 2711 (39%). The patenting in US by inventors from CSIR also tells a similar pattern. There are 461 inventors who produced 7555 patents in US. Analysis indicates that again 19 inventors (4%) produced 155 patents (20%), a highly skewed concentrated pattern of inventor propensity. There are 48 (10%) inventors who produced 227 (30%) patents while 413 (90%) inventors produced 528 (70%) patents. Gupta (2006) also observes that though scientists in CSIR use higher inputs of scientific information than the technical information, but the literature that the CSIR patent applicants cite is less recent patent literature.

Provisional figures from CSIR claim to indicate by its own admission that in the last five years, only 4% of patents in force have been licensed. Compare this achievement with the target of 10% of operational expenditure of CSIR to be realized from intellectual property. The above described record of failure of the CSIR 2001 Vision and Strategy is yet another fact of the liberalisation period.

The strategy contained a whole range of misapplied targets, to which the CSIR system could not be expected to respond favourably. The vision and strategy talked of globalising the CSIR system, making it as a global platform of R&D. It talked of 'patent or perish', when we know that for several parts of the system it was a misapplied target. It had put in too much faith in the market forces, but there was very little favourable response. It went on to withdraw from the societal missions, where the strengths of CSIR system were highly applicable.

The primary function of the Council for Scientific and Industrial Research (CSIR) is to undertake R&D directed towards continuous improvement of indigenous technology and adaptation and development of imported technology. But during the period of his tenure this primary function failed to receive the support of CSIR leadership. Take the available evidence in this regard from the report of the Comptroller and Auditor General of India (CAG, Report No.5 of 2003). This CAG Report tells that of the 984 technologies developed by 23 laboratories/institutes 607 technologies, including 247 developed before 1996-97, were yet to be transferred. It also informs that these laboratories were unable to furnish specific information on the actual expenditure on the development of technologies. Reasons for non-transfer of 246 developed technologies showed that 77 technologies were not found fit for transfer, while 87 required further improvements/developments. Besides, in 82 cases including 34 developed prior to 1999-2000, the negotiations for transfer were under way. CSIR sustained loss of Rs 99.31 lakh due to violation of its guidelines on technology transfer. Royalty/premia of Rs 134.58 lakh remained unrealised in 17 cases of technology transfer.

During the decade of eighties there was at least an attempt to reposition the CSIR for the objective of development of technologies for societal missions and rural industrialisation. Efforts were initiated in respect of several technology missions. During the decade of nineties the structures created for the same purpose were dismantled. In the year 2000, the management even closed down the Division of Societal and Technology Missions (STMD), a nodal point set up for the coordination of this work in the CSIR.

Publicly funded institutions have a very important role to play in technology transfer to the marginal groups. But they continue to lack in the contacts with the bridging organisations. To establish an effective connection with the resources and opportunities available to the poor the CSIR organizations would need the help of bridging organisations. In the absence of this connection technologies that these organizations have created are having a very little success among the rural and urban poor. A complete failure of the policy of liberalisation is evident in the field of technology transfer to the weaker sections.

Transfer and Development of Technologies in CSIR Laboratories

Sr. No.	Name of Laboratory/ Institute	Technologies		
		Developed	Transferred	Lying un-transferred
1.	Central Building Research Institute (CBRI)	92	81	11
2.	Centre for Biochemical Technology (CBT)	23	10	13
3.	Centre for Cellular and Molecular Biology (CCMB)	05	02	03
4.	Central Food Technology Research Institute (CFTRI)	133	27	106
5.	Central Glass & Ceramics Research Institute (CGCRI)	31	11	20
6.	Central Institute of Medicinal & Aromatic Plants (CIMAP)	27	17	10
7.	Central Leather Research Institute (CLRI)	65	04	61
8.	Central Road Research Institute (CRRI)	49	25	24
9.	Central Salt & Marine Chemicals Research Institute (CSMCRI)	28	09	19
10.	Indian Institute of Chemical Biology (IICB)	33	02	31
11.	Indian Institute of Chemical Technology (IICT)	150	130	20
12.	Industrial Toxicological Research Centre (ITRC)	08	04	04
13.	National Aerospace Laboratories (NAL)	05	-	05
14.	National Botanical Research Institute (NBRI)	50	03	47
15.	National Chemical Laboratory (NCL)	NA	NA	NA
16.	National Environmental Engineering Research Institute (NEERI)	37	-	37
17.	National Geophysical Research Institute (NGRI)	04	01	03
18.	National Metallurgical Laboratory (NML)	35	20	15
19.	National Physical Laboratory (NPL)	49	11	38
20.	Regional Research Laboratory Bhopal RRL-Bho.	15	07	08
21.	Regional Research Laboratory Bhuvneshwar (RRL-Bhu)	112	-	112
22.	Regional Research Laboratory Jammu (RRL-J)	14	05	09
23.	Regional Research Laboratory Trivandrum (RRL-T)	19	08	11
Total		984	377	607

3.3 Publicly funded research and transfer of technology

Technology transfer to industry requires two hands to meet to obtain success is a known stylised fact of S&T policy studies. For the advocates of liberalization the example of new technologies such as biotechnology, advanced materials, information

technology etc., are cases of major innovations where after the reforms one expects the success rate to be higher than before. In this subsection, we discuss the evidence accumulating in the case of transfer of biotechnology (BT). Analysis undertaken by Visalakshi (2006) suggests that change for the better is yet to occur; a high amount of failures continue in the case of transfer of biotechnologies. Out of the 60 cases studied only 10-12 cases reached commercial stage. Many of the companies which received the technologies are big companies leaving only a handful of new/small companies which also tried to commercialise BT. Visalakshi (2006) suggests that it is also notable from the analysis that low end and traditional BT propositions face less difficulties during TT in both the periods, that is between 86-95 and 96-05. The high end biotechnology propositions faced difficulties which required high capability to adapt and further develop and commercialise, larger investments in infrastructure and skills, more clear regulatory requirements and favourable and supportive policy instruments and development and promotion of market. Further, Visalakshi (2006) also confirms that though during the period between 96-05 though the technical problems were overcome in many cases but the failures persist in the sphere of investment and regulatory policy, which the state has not been able to sort out due to pressures by different interest groups.

In another study on linkages and commercialisation of healthcare biotechnology, Visalashi (2006) reports the data collected from 80 companies that were surveyed by her during the period of 2003-04. She again confirms the lack of major changes in respect of industry and indicates that the companies, which are having linkages with academic institutions or other companies are less than 50 percent of all the companies surveyed. She also points out that there are many schemes initiated by government agencies but lack of awareness of these and conditions for utilising these schemes have made them less used by the target companies. Added to this some of the cultural and organizational ethos have also come in the way of utilizing the skills, know-how and infrastructure available in public research and academic research to be optimally used for successful innovation and commercialisation of healthcare biotechnology products in India.

3.4 Opening up of the national S&T system to MNCs

The national S&T policy was radically modified to open up the publicly funded structures of research and development (R&D) and technology assimilation to the force of force capital for a wide range of policy objectives. Foreign companies were invited to freely access the publicly funded R&D institutions through the mechanism of contract work. The current policy is to freely permit the foreign companies to set up R&D facilities and venture capital funds in the country for the benefit of development of R&D and technology development. All of these have a totally new set of strategic implications for the processes of integration of research and development (R&D) in to industry.

During this period the new feature introduced in the Indian S&T system is 'R&D by MNCs'. This trend however also posits a lot of potential for mischief. See Box 4.

It is integrating the leading parts of Indian S&T capacity into the regime of global R&D whose benefits from the viewpoint of the national interests are small and the costs can be quite large. The emerging tendency of converting the national scientific and technological capabilities into extensions of the global network of multinational corporations is unlikely to have any major spill over. Attracted by the cheap scientific labour and the scientific and technological infrastructure built up as a result of decades of planning, to an extent multinationals have been always making use of the available opportunities.

BOX 4

R&D BY FOREIGN COMPANIES

SOME PROMINENT INSTANCES OF R&D FEEDING INTO MONOPOLIES

- **Indal works for Alcan.**
- **Ciba-Giegy has Tie up with Hoechest and Winds up R&D Operations after Screening Natural Products.**

SOME CSIR-MNC TIE UPS

- **Duponts for identification of Molecules and Drugs.**
- **Park Davis for Supply of Medicinal Plants.**
- **Abbot Labs for Sythesis of Organic Molecules.**
- **General Electric Company for Intermediate for PolyCarbonates.**

SOME IMPORTANT QUESTIONS

- **Are Emerging Links with Foreign Companies helping to Upgrade Indigenous R&D?**
- **Whether the Needs of National Institutions are met through these Collaborations: While IIT's Tie Up with IBM is Strong on Resource Generation, It is weak in respect of Collaboration.**
- **Will Local Industry be Adversely Affected if R&D is Used by MNC's to Enhance their own Competitive Advantage?**
- **Are Forward Looking Linkages Generated through Collaborations between Industry and Publicly Funded Institutions or Would they Lock out Local Industry Under the New IPR Regime?**
- **Would this Policy take Us Away from the Problems of Modernisation of the Existing Labs and Lock them into a Linkage Regime, which has as narrow a focus as it had**

BOX 5

S&T INSTITUTIONS AND LOCAL INDUSTRY PARTNERSHIP

- **Income from royalty and premia for the CSIR laboratories remains a small component.**
- **For the CSIR laboratories consultancy continues to be still the main source of income from private sector units.**
- **Pressure for raising the external cash flow Exists: CSIR to needed more than 2000 projects to Meet Its External Cash Flow Needs.**
- **This Put Tremendous Pressure on the System in Which only 5000 Scientists were working having Negative Consequences for CSIR Systems and its Coherence.**

Under the post-1991 liberalisation policy regime the foreign companies are being allowed direct access to the national R&D system. Today the foreign companies appear to be better placed than the national companies in respect of the access to S&T infrastructure. This means that the forces in S&T infrastructure which so far drove S&T in India will be either put on to the co-option road or driven to become extinct by its new policies. The country has been induced to open up the national laboratories to the foreign companies for contract research in those fields where the Indian companies' interests are highest.

It is significant that the CSIR institutions have been induced to get into the collaborative arrangements with foreign companies in those sectors where the strategic interests of the Indian industry are high. This option has been preferred by the CSIR partly because it has been constantly for the last two decades under heavy

criticism for not being able to hit big in the area of indigenous technology development. But this is hardly a good way of proving itself as the process of putting these institutions into foreign contracts can also hurt the national system of innovation. Even in this latest phase of the post liberalisation regime the collaborative R&D programmes in which publicly funded laboratories would be partnering with the local industry are still a far cry as shown in Box 5.

3.5 Failure in respect of articulation of demand for indigenous S&T

The government can use the publicly funded R&D institutions in a bigger way if it sees itself also as a creator of demand in the area of indigenous technology development. Let us not forget that it is only in areas such as agricultural research, space, atomic energy and defence research where strong, often non-economic demand inducement mechanisms of the government were at work that significant advances took place. For science and technology (S&T) the period of economic liberalisation has been a period of the system coming face to face with its continuing weak links with the people's needs and resources. Throughout the period the consequences of its systemic failures have recurrently come home to the nation. In respect of many important sectors there has been an open expression of dissatisfaction with the solutions and services provided to by the structures of S&T among the state governments. Within electronic and print media S&T has been under close scrutiny for the technologies of weather forecasts and the solutions that the S&T institutions recommend for the control of floods and drought. In some cases the source of trouble identified has been those very solutions that business and institutions continue to impose on the people in the name of latest technologies. The available technology implementing structures are not at all competent to tackle the problems of rising import dependence on petroleum products, growing incidence of severe outbreaks of crop diseases, explosion in the recurrence of communicable diseases, worsening water and air pollution and other such issues that affect the poor. This has also sent out a message that the problems of restructuring of S&T are certainly not an issue of only funding or better integration and co-ordination among different experts but also of its reorientation. It would not be an exaggeration to claim that the national innovation system is being induced to take one step further in the direction of disconnection's of S&T system with the people's needs and resources. The government is negligent of the concerns relating to impacts of the introduction of new technologies on self-reliance, equity, employment, health and safety of people. Across sectors the question of "new technology for whom" is being ignored in the implementation of the policies formulated on technology import, intellectual property rights and biodiversity conservation, agricultural development, energy, transport and education.

Even in respect of IT though at the level of policy perspective the government has been laying much stress yet the irony is that the increases in budgetary allocation have been myopic. The government took the step of setting up of the Ministry of Information Technology (MIT) on 15th October 1999 with many fanfares. The objectives given to the Ministry for fulfilment were quite ambitious. The Ministry is to accelerate the Internet revolution in India, emphasizing the creation of useful contents in Indian languages, IT-enabled services, IT education, electronics and computer hardware manufacturing, and exports, silicon facility, e-commerce and Internet based enterprises. As a nodal mechanism the Ministry has been entrusted the task of implementation of a comprehensive action plan to make India an IT

Superpower in the early part of the next century and achieve a target of $ 50 billion in software exports by 2000. Since the Ministry has been designated as the nodal institutional mechanism for facilitating all the initiative in the Central Government, the State Government, Academia the Indian private sector and successful Indian IT professionals abroad, it was natural to expect that its budget would be considerably enhanced.

The report issued by the Parliamentary Standing Committee is quite illuminating on the details of the myopia that follows from the incremental budgetary approach. Its finding is that though the allocation for the year 2000-2001 is Rs. 197.20 Crores more than of 1999-2000 but this enhancement is largely a consequence of the merger of National Informatics Centre (NIC) and Electronics and Computer Software Export Promotion Council (ESC) into the Department of Electronics (DOE). It reveals in detail about how even this year the increase in allocation to IT is marginal. It reports that the allocation for NIC would be utilised mainly towards its on-going activities. The Committee states that it has failed to understand how NIC will catch up with rapid advances being made in this field as a result of technical innovations. The Committee observes that the Ministry should review its priorities and if necessary, come out with additional financial projections at Revised Estimates (R.E.) stage.

The same Committee also notes that the Technology Development Council (TDC) programme aiming to support research, design, development and engineering in the areas of computer and computer communications, control and instrumentation, consumer electronics, telecommunications and broadcasting has not been able to use even its meagre provision of Rs. Eight Crores. The same is again repeated for the Industrial Electronics Promotion Programme (IEPP) that aims at development and application of Electronics &Information Technology based products and systems to improve productivity, quality and safety in the industrial sector. The Committee asks the Ministry to ensure proper co-ordination between the Ministry and the executing organisations so that the dismal performance of the past regarding non-execution of projects is not repeated. The Committee also notes with great concern that hardware sector is showing reverse trends and as such has made little progress. It therefore recommends, the Ministry should endeavour to bridge the gap between hardware and software sectors by chalking out concrete plans for speedy promotion and development of hardware export in the country. In a sceptical tone, the Committee also notes of the slow progress made in the important department's programme entitled "Electronics for Rural/Social/Agricultural/Water Sector". The Committee feels that the Ministry should utilise the allocation for the programme for the benefit of maximum number of rural people

3.6 Patterns of S&T investments by user departments

The approach to budgetary allocation for most of the S&T budgets of user departments has remained one of incremental increases in the non-plan. See Box 6 for the state of User departments R&D during the nineties.

BOX 6

DECLINE IN USER DEPARTMENTS' R&D

No increase in S&T for Sectoral and Regional needs

- **S&T allocation of less than 1% in the Ministries of Coal, Power and Rural Development, and less than 0.1% by the Railway Ministry.**
- **The States and the Union Territories, all put together, had 8th Plan outlay of less than Rs. 200 Crores for science and technology during the whole plan period of 5 years.**
- **The percentage allocation of Agricultural Gross Domestic Product for Agricultural Research and Education by the developing and developed countries: 0.5% and 2.39% respectively in Last 5 Years.**
- **Agricultural Research and Education In India: Investment was 0.28 % and 0.128% for the years 1997-98 and 1998-99 (Parliamentary Standing Committee on Agricultural).**
- **Parliamentary Committee recommends outlay for DARE/ICAR in the IXth Plan to the level of 1% of agricultural GDP.**
- **This year the Committee noted that increase in plan expenditure is mere 9.77%, which is far from adequate, and it has again strongly reiterated its earlier recommendation of increasing the allocation to agricultural**

3.7 Human resources for S&T under liberalisation

For a balanced development of the national system of innovation for a country like India it is quite critical that the support provided by the government to the sector of universities and technical institutions does not suffer due to financial constraints. Plan funding for the development of higher education has not increased in proportion to increase in allocation of funds to allocation. The plan allocation during the IX plan is slightly less than eight percent. Over the period 1990-97 the share of expenditure on Higher Education to total expenditure on Education both by Central and State has declined successively from 14.7% to 11.5%. The decline is greater in the case of Central Sector i.e. from 32.2% to 15.7%. Expenditure on Higher Education as % of GNP has gone down considerably. It is less than one half of what was in 1981. Most of students enrolled in higher education are pursuing the traditional programmes of studies, i.e. arts, science and commerce, which in fact are least cost programmes as compared to other professionals and vocational oriented programmes. The priority shifts in favour of revenue generating courses and short duration education and crash courses are visible. The budgets on libraries, laboratories and similar facilities are severely affected. The central government's plan expenditure on research by Department of Education has come down in a very big way. Research in technical education has suffered severely. The fine distinction between higher education and training is getting lost.

There is a decline in the availability of manpower capable of taking up R&D. Apart from viable financial support the most critical input for R&D is manpower. While India has a large strength of S&T personnel of over 6.3 million, the number of scientists actually engaged in R&D is only about 150,000. The government must make investments in S&T to attract students back to the post-graduate studies in science and engineering. A clear drop in enrolment in basic sciences is visible. The percentage of those students who take up basic science as their course declined from 30% to 19.6% in a matter of three decades. In the field of post-graduate education and research in engineering and technology the situation is equally worrisome. The

average turnout of Master's Degree holders in engineering and technology is only around 5000 per year and this is against the capacity of more than 15000.

To save the situation the concept of an assured placement to the doctorates and post-graduates in engineering and science is now necessary. Otherwise it seems that this decline will continue. There is nothing in the last three budgets to give a feeling that the government now understands the problems and is willing to invest in a big way in R&D and higher education. With the increase in fellowship money, which followed the recommendations of the fifth pay commission, the government should have also increased the grant to UGC and CSIR if it was serious about encouraging the agencies to provide more fellowships so as the trend of declining enrolment is reversed. The funds provided to these agencies are not even sufficient to maintain the existing level of fellowships. These agencies have been forced to reduce the number of fellowships.
There is no change in the pattern of funding to the educational institutions. They are likely to consume their allocation mostly in the payment of salaries. It means that the impact of increased salaries will not get translated into making an impact on the students getting attracted to the careers in engineering and science. There will be hardly any money left to support R&D in the institutions after the payment of salaries. The initiatives that the CSIR and DST have been promoting in respect of encouraging young talents to take up research oriented careers as a tokenism are insufficient to counter the tendencies of young minds getting attracted to IT-a big brain sink at present. The last available out-turn data for doctorate degree holders reveals that from 95-96 to 96-97 there has been a drop in the science faculty from 3861-3498 and in the engineering faculty from 374 to 298 respectively. A known fact may be mentioned here that the industrial success of Southeast nations is based on the human factor of engineering excellence, to which engineering research makes a major contribution.
Similarly, there existed an expectation that the government would also be allocating now higher level of resources in favour of all those priorities that the private sector usually neglects. But the allocations made to MIT this year appear to have again followed an incremental budgetary approach.

Section 4. An alternate framework for an analysis of the impact of liberalisation on technological performance

Coming to the issue of limitations of the theoretical framework of analysis that the policymakers continue to adopt to make their case for large firms, liberalization and deregulation, it is our understanding that the debate among both academics and policymakers on the policy of liberalization was and is still informed by the heroic conception of the origin and direction of major innovations. Within the above-discussed contours of the academic discourse the systemic conception of innovation was and is today in many cases still absent. Even today there is very little discussion on how the technological inter-relations and interdependence would be affected by the policy of liberalisation. As a result there is again not much discussion on how the role of the government could be shaped in respect of coordination and regulation of the firm level interconnections when the licensing controls and reservation would be removed.

As an alternate explanation, we suggest that in a latecomer country the instruments of development planning have to play the role of providing for technological coordination to achieve the economies of scale and scope in the national system of innovation to alleviate the constraints of size of both the firm as well as the market. In

our view, the failures that the country has particularly experienced in respect of technological performance on account of the implementation of liberalization are far better explained using the framework of analysis of the non-fulfillment of the requirements of technological coordination.

It is the surmise of this paper that the selected policy regimes of liberalization allowed freedom to the Indian corporate sector to grow and develop their nexus with the foreign firms and finance in such a way that in many sectors it became impossible for the nation to achieve necessary technological coordination to realize the economies of scale and scope in the national system of innovation. Leaving aside a few selected sectors where also the corporate sector has been now allowed to capture the national economic space and direct the technological activity with a myopic outlook, changes in the policy of licensing controls and reservation were made without any kind of intervention being envisaged from the side of the government in the nature of technological choices and the pace and orientation of capability building processes. As a result the nation is today experiencing a failure of technological coordination of the systemic dimension of the process of innovation. Similarly, in respect of the role of government in the articulation of demand, the inability to integrate the forces of S&T with the development process at the sectoral and inter-sectoral levels is in the case of pharmaceutical and automotive sectors evident once again from the absence of health and transport planning. Problems being experienced in respect of involving the corporate sector for the realization of the benefits of self-reliance and people oriented development in the economy through the processes of " development planning" in the case of BT and IT are also well evident where the government has been unable to use the instruments of regulation and market articulation to generate appropriate domestic demand.

Importance of the failure of technological coordination and market articulation has been analyzed in a counterfactual way for namely pharmaceuticals and automotive sectors. It has been shown that where the government was able to leverage the controls over market access to foreign companies and provide the corporate sector with the backward linkages it has been able to do better subsequently in terms of growth performance. Joseph and Parthasarthy, 2004 also seem to confirm that the new big business groups in the IT sector that are growing today using the route of outsourcing would have been seriously handicapped if the government had not exercised the market controls in the selected segments of electronics and telecommunications during the eighties.

Even in the case of capital goods and machinery sector, where the domestic markets were protected and not open to external competition during the eighties, there is evidence that the Indian government had a better control over the process of technology imports. The selected policymakers could utilize the space to negotiate with the foreign companies to obtain technology in lieu of the grant of access to domestic market for the development of public sector in these segments. Foreign companies were tempted to part with their technologies in lieu of the grant of share in a vast domestic market. Particularly for those public sector units that were interested to use the grant of access of market in lieu of the acquisition of foreign technologies

from the technology supplier control of the governments over the domestic market did serve as an important tool of bargaining[16].

In conclusion

Analysis undertaken in this paper of the available evidence on the patterns of technological accumulation and innovation clearly indicates that in spite of external and internal liberalization the corporate entities have not become proactive in India in the conduct of technological activities for the creation of new products and systems. The policy regimes of liberalisation, which allow the large private sector enterprises of both domestic and foreign origin to operate freely, have not been able to ensure the rate of technological accumulation to grow to a level to give opportunities and conditions to large domestic firms to become independent and capable of the introduction of major innovations. They are also not able to determine the directions of technology to move in favour of meeting the needs of the people as a whole. Be the experience of implementation of scientific and technological self-reliance in the engineering industry under market-oriented reforms during the phase of internal liberalization or the consequences for essential medicine production in the post-liberalization development of pharmaceutical industry during the phase of external liberalization, all of these confirm that the newly selected routes of technological accumulation have a tendency to limit the role of Indian firms to one of unequal partners in the emerging international division of labour. Their technological activities are geared to promoting an unbridled commodification of the services and products.

The strategic technological behaviour of large domestic firms is largely geared to promoting the integration of the local manufacturing base and other domestic technological facilities with the emerging patterns of global economy in an unequal manner. In India, under the selected path of liberalization innovations implemented by the large private sector firms are geared to promoting unhealthy lifestyles through the individualisation of consumption of cars and drugs within the Indian society rather than meeting the real needs. The national innovation system is moving away from the goals of a wider notion of competitiveness and can be today termed as highly negligent of the innovations that are relevant to the well being of the 'common man and woman'. Its innovation capacity has become skewed and vulnerable to the potential technological and institutional lock-ins due to the growing integration of the technological plans of the corporate sector with the priorities of the western markets.

However, the selected path of 'development' which entails both external liberalization and deregulation is in strategic sense a route of choice now for the large Indian firms. As far as the advocates of liberalization among the policymakers are concerned, their ideological rhetoric continues to be that by giving the big business total freedom to operate they are unleashing the big business groups to upgrade themselves

[16] For example, this did enable the Indian public sector units e.g. Bharat Heavy Electrical Limited (BHEL), Bharat Electronics Limited (BEL), Electronics Corporation of India Limited (ECIL), Hindustan Aeronautics Limited (HAL), Hindustan Machine Tools (HMT), Oil and Natural Gas Commission (ONGC), etc. to obtain relatively newer versions of technologies. To cite Ashok Parathasarthy who recently retired as a Secretary to the Government of India and has had the experience of negotiating with the foreign companies on behalf of the public sector units, "I have personally obtained many technology licenses without a single restriction in the segments of microelectronics and advanced computing because the government could use the grant of market access to the foreign companies in lieu of technology supply" (Parthasarthy Ashok, 2004).

technologically for the nation's long-term benefit. More incentives are being offered to the corporate world to get ready to exploit the opportunities becoming available through the emerging growth routes. Alliance building with the foreign companies for the exploitation of the markets at home and abroad through the SEZs is becoming a key vehicle for attracting the investors to come to their states by the state governments, which are now competing among themselves on the offers of incentives. And all of this is happening without even asking the question that whether actually in this way major innovation is getting stimulated and diffused to bring about a radical technical change in the economy. In this way with the full backing of market forces the dominant mainstream neo-liberal policymaking tendency today essentially drives the dynamics of development of national system of innovation (NSI) in India.

It is also evident that small size of the domestic market came to appear as a key constraint for the further growth of firms originating from India. In the Indian case, this reason too made the Indian big business to clamour, on the one hand for the relaxation of restrictions put on foreign direct investment and technology imports, and on the other for the hastening of the process of privatization of the Indian public sector. Furthermore, with the dismantling of the market access controls a serious problem had been created in respect of the acquisition of foreign technology. Advanced technology cannot come with the environment of unregulated foreign direct investment. With the external liberalisation fully in place the main problem facing the acquisition of foreign technology is the loss of control over internal market. Domestic firms have lost an important bargaining tool. Not too many among domestic firms are in position to force the MNEs to enter into non-strategic alliances and obtain better technologies. The government has been willing to grant almost for asking very important concessions to the foreign investors. In those sectors where essentially the investments have been made for the location of export oriented production and R&D during the period of liberalisation in India, the patterns of technological accumulation are increasingly getting driven by the strategic behaviour of developed countries' foreign firms.

The process of transformation of Indian systems of innovation has been guided by the vision that the nation needs to implement in every sector at all levels the policy reforms aiming to consolidate a process of institutional transformation which facilitates the market confirming organizations and institutions while discouraging the emergence of organizations and institutions which limit private exchange and the functioning of the price mechanism. The governments in power through the media projected the failures experienced in respect of declining competitiveness of the industrial sector, stagnating incomes and growing technological obsolescence and economic inefficiencies, infrastructural gaps emerging in respect of energy, transport, communications, housing, health and education, emerging fiscal and trade imbalances and unemployment as their chief rationale for the implementation of the institutional changes linked to the process of economic liberalization. It was argued that the government should get out of the economy and leave it to the business groups to clear the mess that has arisen on account of the implementation of the strategy of economic dirigisme to obtain the targets of socio-economic development during the pre-liberalization period. In India, it is not however difficult to realize today for anyone that there is a mismatch between the peoples' aspirations and outcomes being achieved in respect of employment and livelihood security, energy and transport problems, disaster management, income distribution, linkages and synergies.

The patterns of integration of technological and industrial investments that are emerging under the influence of the policy of liberalisation seem to be completely oblivious of the goals concerning non-renewable energy conservation, fuel economy, energy self-reliance, environmental health, water scarcity, water pollution, neglected diseases, human health, and such other issues. The policy regimes that are now under implementation are likely to drive the country towards her own people effectively losing their grip over the directions of innovation and technology diffusion. Having been unable to develop the economies of scale and scope in the national system of innovation the Indian state is going to allow the corporate sector to become an integral part of the strategies of western firms.

Finally, it is our plea that as a policy corrective only through the restoration of the role of technological coordination to the instruments of technological planning we can begin to change once again the directions of technological capability building and technological performance and reintegrate the Indian corporate sector into the plans of the Indian people. The country urgently needs an alternate direction with respect to the policy reforms to ensure a different kind of systemic transformation of the Indian innovation systems so as the policymakers can give the corporate and public sector alike a new strategic vision and a set of goals to work on and coordinate with each other for the benefit of Indian peoples' needs using participatory development planning tools.

References

1. Alam, G (1988) India's Technology Policy: Its Influence on Technology Imports and Technology Development, in Technology Absorption by Indian Industry, edited by Desai Ashok, 135-156, New Delhi, Wiley Eastern
2. Alam, G. (1993) ' Research and Development by Indian Industry: A Study of the Determinants of its Size and Scope' *Mimeo,* Centre for Technology Studies, New Delhi.
3. R. Basant and P. Chandra (1999), "Building Technological Capabilities in a Liberalising Developing Economy: Firm Strategies and Public Policy", INTECH, the UNU, 1999.
4. Chandersekhar & Ghosh (2002) The Market that Failed: Neo-liberal Economic Reforms in India, Leftword, New Delhi
5. DSIR, Annual Report, 1985-86, 1997-98, 1998-99
6. Desai, A.V. (1980) 'The Origin and Direction of R&D in India' Research Policy, 9(1), 74-96
7. Desai, A.V. (1984) 'India's Technological Capability: An Analysis of Its Achievements and Its Limitations' *Research Policy*, 13, 303-310
8. Desai, A.V. (1985) 'Market Structure and Technology: Their Interdependence in Indian Industry' *Research Policy 1*4, 161-170
9. Desai, A.V. (1988) edited Technology Absorption by Indian Industry, New Delhi, Wiley Eastern
10. Desai, A.V. (1990) 'Recent Technology imports into India Results of A *Survey' Development and Change*, 21, 723-49
11. GOI, Research and Development Statistics 1994-95, DST, New Delhi, September 1996.
12. GOI, DSIR, Research and Development Statistics, 1996-97

13. Jacobsson, S. and Alam, G., Liberalization and Industrial Development in the Third World: A Study of Government Policy and Performance of the Indian and Korean Engineering Industries, Sage Publications, 1994
14. Manmohan Singh (1995), Science, Technology and Economic Performance, Yojana, Planning Commission, New Delhi
15. M.Padma Suresh, Non-Electrical Machinery Industry, in the National Workshop on Strategic Approach to Strengthening International Competitiveness in Knowledge-based Industries, Research Information System for the Non-Alligned and Other Developing Countries, New Delhi, August 13, 2004.
16. Parthasarthi, A. (1987) 'Acquisition and Development of Technology' *Economic and Political weekly*, Nov. 28, M131-M138.
17. Parthasarthi, A. (2004) Acquisition and Development of Technology: The Indian Experience, in the National Workshop on Strategic Approach to Strengthening International Competitiveness in Knowledge-based Industries, Research Information System for the Non-Alligned and Other Developing Countries, New Delhi, August 13, 2004.
18. Dhar B & Rao N (2002) Transfer of technology for successful integration in the global economy: A Case study of pharmaceutical industry in India, UNCTAD Investment Policy and capacity building branch, *UNCTAD/ITE/IPC/Misc.22*
19. Kumar Nagesh (2003), Liberalisation, outward orientation and in-house R&D Activity of multinational and local firms: A quantitative exploration, Research Information System for Non Aligned Countries (*RIS)*, New Delhi RIS Discussion Paper #07/20002.
20. Narsalay R (2000) *Pharmaceuticals* Paper presented at the Seminar on cross-border Mergers & Acquisitions and sustained competitiveness in *Asia, Trends, Impacts and Policy Implications, Bangkok*, March 9-10.
21. Upadhyay, V, Ray, A & Basu, P (2002) A socio-economic study of the role of in-house R&D in Indian Industry: A Case Study of Pharmaceutical and Tyre Sectors, *Department of Science & Technology*, Government of India, New Delhi, March 2002
22. Siddharthan (2004), Globalisation: Productivity, Efficiency and Growth, Special Number on Industry and Management, 1, 31 Economic and Political Weekly, Mumbai
23. Subrahmanian, KK 1987: 'Towards Technological Self reliance: An Assessment of Indian Strategy and Achievements in Industry', in PR Bramananda and VR Panchamukhi (eds.), The Development Process of Indian Economy, New Delhi: Himalaya Publishing House, Pp. 420-446.
24. Subramanian, K.K (1991) 'Technological Capability under Economic Liberalism : Experience of Indian Industry in Eighties', Economic and Political Weekly, August 31, M87-89.